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ABSTRACT

This guide, developed for the chemistry 200, 300 program in Manitoba, is designed to articulate with previous science courses, provide concepts, processes, and skills which will enable students to continue in chemistry-related areas, and relate chemistry to practical applications in everyday life. It includes a program overview (with program goals and objectives for chemistry 200 and 300), information for implementing the program, and unit design charts for chemistry 200 and 300 core and optional topics. Chemistry 200 core topics include the periodic table and its elements, matter, organic chemistry, gases, and solutions; optional topics include chemistry of photography, energy, polymers, chemistry of food additives, and chemicals as drugs. Chemistry 300 core topics include electronic structure, bonding, and the periodic table; reaction rate and chemical equilibrium; ionic equilibrium (acids and bases); solubility; and oxidation/reduction reactions; optional topics include analytical chemistry, metallurgy, consumer chemistry, environmental chemistry, and the chemistry of food production. Provided for each of these topic areas is the rationale for its inclusion into the course, recommended time, and objectives (with each objective keyed to suggested activities and references). (JN)

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chemistry 200, 300

interim guide

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department of education

CHEMISTRY 200, 300

INTERIM GUIDE

1984

Province of Manitoba

Department of Education

THIS GUIDE IS SUBJECT TO REVISION ON THE BASIS OF INFORMATION RECEIVED FROM SCHOOLS. IT IS EXPECTED THAT MODIFICATIONS WILL NOT BE IN THE DESIGN OF THE PROGRAM. RATHER, CHANGES MAY BE MADE IN AREAS CONCERNING STRATEGIES, RESOURCE MATERIALS, AND IMPLEMENTATION.

ISBN 0-7711-0159-7

This interim document was prepared by the Department of Education to meet the needs of students in Manitoba. The pilot guide was tested in Manitoba schools from 1981 to 1983, and has been revised on the basis of feedback obtained from teachers and students.

The course has been designed to articulate with previous sciences, provide concepts, processes, and skills which will enable students to continue in chemistry-related areas, and relate chemistry to practical applications in everyday life.

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program implementation

PROGRAM OVERVIEW

RATIONALE

> A general education in the sciences should make it possible for people to appreciate the worthiness of the scientific enterprise and to use its achievements for attacking contemporary problems as well as designing the future we seek.[1]

The increasing impact of science on our lives and the changing needs and abilities of high school students makes a periodic review of high school science courses necessary. The K-12 Science Working Party undertook such a review of the chemistry curriculum in order to determine what if any alterations needed to be made in either content or design. After surveying high school chemistry teachers in Manitoba and studying the literature on chemical education, the Working Party concluded that 1) the number of recommended topics should be decreased; 2) a study of the relationship of science, technology and society should be introduced; and 3) the program should be related to the developmental level of students.

The number of topics was decreased for two reasons: to provide greater flexibility in the program and also to provide for a better articulation with post-secondary institutions. Meetings with representatives of those institutions produced a clearer understanding of their expectations of graduating students--what students are expected to know and what they are not expected to know. As a result, some changes were made in the content of the program; for instance, emphasis on molecular orbitals and molecular structure was decreased and emphasis on descriptive chemistry and on concrete activities was increased. These changes are consistent with those recommended in the literature on chemical education. For instance, the majority of respondents to a survey of chemistry professors in southern California advised

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[1] Paul Dehart Hurd, "Scientific Enlightenment for an Age of Science," The Science Teacher, Jan. 1970, p. 15.

> high school teachers to focus on fundamental chemistry principles. . . The "basics" often cited were: chemical nomenclature, formula writing and percentage composition calculations, balancing equations, gas laws, the mole concept and simple atomic theory. "Forget about quantum mechanics, molecular orbitals and free energy," they said.[2]

Another report indicated that there should be:

> more appropriate emphasis on the reactions, properties, and applications of chemical substances: in short, on descriptive chemistry.[3]

A new emphasis on descriptive chemistry has been added as well as some of the basics mentioned above. It is in the core of the program that the basic concepts and skills required of students who intend to pursue post-secondary study can be found.

The study of the interaction of science, technoloy and society is introduced in the option units. These units--five in all for each program, from which two are to be chosen and completed--are a new addition to the program, constituting twenty to twenty-five percent of it. Dealing with the applications of chemistry, they represent a broadening of the bases on which the study of high school chemistry rests. The units are devoted to such topics as energy, the chemistry of drugs, the chemistry of food additives (200), metallurgy, analytical chemistry and environmental chemistry (300). The way in which the units relate to this area of study vary. Some deal with the interdependency of science and technology; others with their role in increasing material comfort; still others with the environmental impact of scientific and technological developments and alternative solutions to scientific, technological and environmental problems.

The new curriculum is based to a greater extent than before on an understanding of the cognitive development of high school students--the level they have reached at the time of entering the program. Recognizing that many students who enroll in chemistry have not progressed past the concrete operational stage, the committee has provided opportunities in the course for students to move from this stage to the formal stage of reasoning which is necessary for much of the study of chemistry. For this reason, there are now included concrete activities; opportunities for students to apply principles in a variety of situations, to use proportional reasoning to evaluate and reconsider their solutions; and occasions for students to move from the qualitative to the quantitative.

In summary, the new Chemistry 200 and 300 programs are designed to provide students with a firm grounding in the concepts and processes of chemistry, an understanding of the factors which influence the applications of chemical principles and an opportu-

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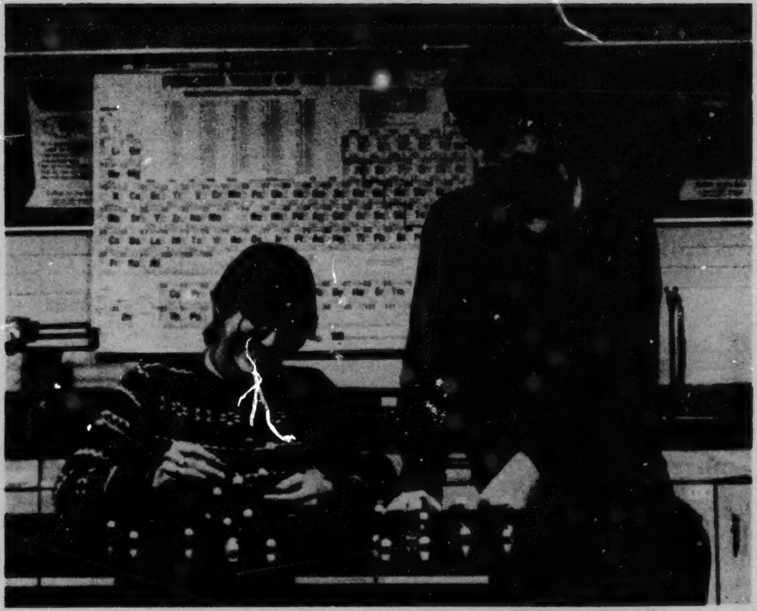
[2] Eric Streightberger, "What Should We Be Teaching Them in High School Chemistry?" The Science Teacher, Nov. 1977, p. 36.

[3] H. Bent et al, "Report on Conference on New Directions in the Chemistry Curriculum," Journal of Chemical Education, 55 (12), 818.



nity to experience growth in cognitive ability. Such growth and development will help prepare them to live in a world of ever increasing complexity.

PSYCHOLOGICAL BASIS OF PROGRAM DESIGN

The design of the Chemistry 200 and 300 program is premised on what is presently known about the intellectual development of secondary students--the abilities with which they start when they enroll in the program and those which they must develop to satisfactorily complete it. Although chemistry students may be more advanced in certain patterns of thinking than their peers, they nevertheless need the opportunity to use and develop these patterns. One study has shown that "from 25% to 75% of high school and college students do not successfully use such components of formal reasoning as 1) using proportions; 2) making quantitative correlations; 3) making all possible combinations; and 4) controlling variables."[4] Many students use concrete reasoning patterns on subject matter that requires formal thought. If chemistry courses are to be open to as many students as possible, not just to those who use formal processes easily, then the development of formal reasoning skills must be an important course objective.[5] It is an important objective in the newly revised curriculum.

In revising the curriculum, the designers have attempted to identify the reasoning pattern required for the mastery of a particular concept and provide suitable activities for its development. They have reduced the content of the program so that students can develop concrete definitions of concepts and apply them in a variety of situations to extend the range of their meaning. The reduction of content also makes it possible for students to master those subconcepts which are essential for the development of formal thought.

The committee has placed increased emphasis on descriptive chemistry. As one study has noted: "before one can reason with hypotheses and deductions based on experience, there must be a sound descriptive base which has been set in order.[6] The committee has also encouraged the use of laboratory activities and concrete exemplars such as models. These, particularly the laboratory activities, provide experiences which will enable students to develop hypotheses and deductions. They are the means by which they will gain skill in comparing conflicting data, in solving problems that include both relevant and irrelevant data, and in manipulating variables in both an open and a closed manner. Studies have suggested that benefits from the experience with laboratory activities and models accrue not only to learners at the concrete stage of development but also to those who have already reached the formal operational stage.[7]

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[4] R. Good et al., "Piaget's Work and Chemical Education," Journal of Chemical Education, 56 (7) 428.

[5] Robert Karplus, "Science Teaching and the Development of Reasoning," Journal of Research in Science Teaching, 14 (2), 173.

To ensure a link between theoretical knowledge derived from both textbook study and laboratory activities and the application of this knowledge, the committee has reintroduced the study of technological process. The transfer of knowledge accomplished in this way aids the development of formal reasoning skills.

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[6] J.D. Herron, "Piaget in the Classroom," Journal of Chemical Education," 55 (3), 169.

[7] Alan Wheeler and Heidi Kass, "Student Misconceptions in Chemical Equilibrium," Science Education, 62 (2), 231; and Madeline P. Goodstein and Ann C. Howe, "Application of Piagetian Theory to Introductory Chemistry Instruction," Journal of Chemical Education, 35 (3), 173.

CONCRETE AND FORMAL REASONING PATTERNS[8]

Concrete	Formal
A student at the concrete level: 1) Needs to refer to familiar actions and observable properties. 2) Uses the following reasoning patterns: a) applies classifications and generalizations based on observable data; b) applies conservation logic; c) applies serial ordering and establishes one-to-one correspondence between two observable sets. 3) Needs step-by-step instructions in a lengthy procedure. 4) Is not aware of own reasoning, inconsistencies among various statements he/she makes, or their contradictions with known facts.	A student at the formal level: 1) Can reason with concepts, relationships, abstract properties, axioms, and theories; uses symbols to express ideas. 2) Uses concrete patterns applied to abstract properties and theories as well as: a) applying combinational reasoning, considering all conceivable considerations; b) stating and interpreting functional relationships in mathematical form; c) recognizing the necessity of an experimental design that controls all variables but the one being investigated. 3) Can plan a lengthy procedure given certain overall goals and resources. 4) Is aware and critical of his/her own reasoning; actively seeks checks on the validity of his/her conclusions.

GOALS OF THE CHEMISTRY 200, 300 PROGRAM

Although high school science courses vary in content, they all contribute to students' scientific literacy. They also aim for similar goals. These are:

1. To increase the student's knowledge of basic concepts in selected topics in chemistry so that he or she will be able to:

   a. interpret and evaluate fundamental ideas;
   b. relate scientific concepts to everyday life;
   c. make informed choices about future studies or careers.

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[8] Karplus, p. 171.

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2. To enable the student to develop and use the skills of science. These skills include:
   - a. science process skills;
   - b. interpretative and computational skills based on collected data;
   - c. communication skills related to the gathering and interpretation of information;
   - d. those psychomotor skills which are required for first-hand investigations.

3. To develop the student's interest in and appreciation of scientific values and problem solving and to promote attitudes such as curiosity and open-mindedness, respect for accuracy and precision, the tentativeness of evidence, and the principle of causality.

4. To promote an understanding of the relationship between chemistry, technology and their impact upon the individual and society in order to help the student to:
   - a. recognize that science and technology are interdependent:
     - 1) science is dependent upon technology for tools, techniques and the formulation of basic ideas;
     - 2) technology is dependent upon basic science for the development of new knowledge;
   - b. recognize the human tendency to reject theories and research findings that conflict with tradition or accepted practices;
     - 1) recognize that scientific activities and results are regulated by a set of values;
   - c. describe the difficulty of preventing unforeseen side effects from occurring as a result of efforts to control imperfectly understood natural process;
   - d. recognize the finiteness in the supply of most raw materials that are now in demand;
   - e. explain the role of science and technology in increasing human material comfort:
     - 1) describe the interdependence of human material comfort and environmental effects;
     - 2) describe the economic cost of human material comfort and its interdependence with the level of consumption of energy and raw materials;
   - f. examine alternative solutions to scientific-technological-environmental problems;
     - 1) understand the limits of scientific knowledge relative to solutions of present problems;
     - 2) recognize the trade-offs, technological and economic, which are necessary to solve problems;
     - 3) develop a concern that the public and industry assume responsibility for maintaining or improving the quality of life for future generations;
   - g. develop decision-making skills to solve problems:
     - 1) identify the significant elements and implications of an issue;
     - 2) distinguish among facts, opinions, beliefs, conclusions, and value judgements;
     - 3) identify logical relationships among the elements of an issue;

   - h. relate science-technology to leisure time activities.

OBJECTIVES FOR CHEMISTRY 200

CORE UNITS

Unit A: Introduction to the Periodic Table and the Elements

1.0 Describe the atom as to position, relative mass and charge of protons, electrons, and neutrons.

2.0 Differentiate between the atomic number and the atomic mass of an element.

3.0 Define the isotope.
  3.1 Identify the isotopes, given the atomic numbers and mass numbers for a group of atoms.

4.0 Distinguish between atoms and molecules, elements and compounds.

5.0 Relate the name of an element and its symbol.

6.0 Know the names and symbols of the following common elements: H, Li, Na, K, Mg, Ca, Sr, Ba, Cr, Mn, Fe, Ni, Pt, Cu, Ag, Zn, Hg, Al, C, Si, Sn, Pb, N, P, O, S, F, Cl, Br, I, He, Ne, Ar, U.

7.0 Distinguish between a group (family) and a period with regard to its position on the periodic table.

8.0 Locate the following groups on the periodic table: Alkalies, Alkaline Earths, Chalcogens (oxygen family), Halogens, Inert Gases.

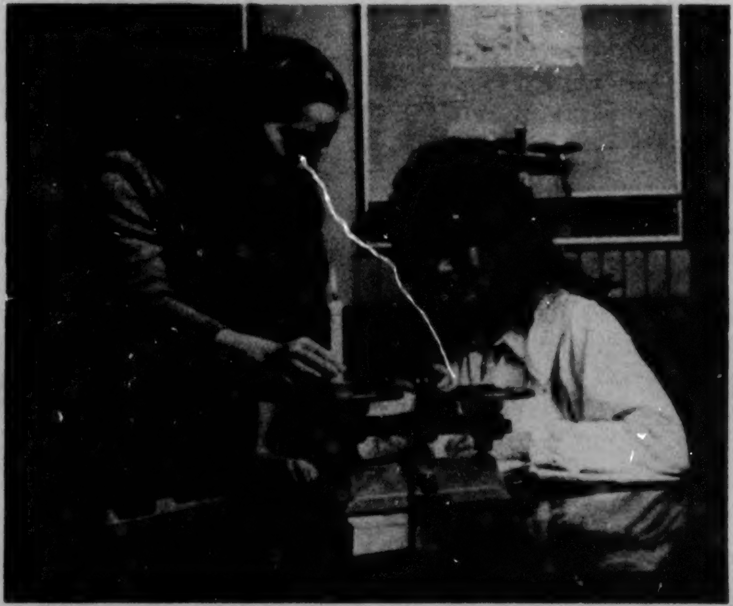
9.0 Observe, organize, and classify elements in terms of appearance, metallic and non-metallic properties.

10.0 Relate metallic and non-metallic properties to the periodic table.

11.0 Distinguish between an atom and an ion in terms of gain or loss of electrons.

12.0 Predict the charge of a simple ion from its position on the periodic table.

13.0 Write and name formulas of compounds formed between elements from the following groups: the Alkalies and Alkaline Earths with the Chalcogens (oxygen family) and the Halogens.



14.0 Write and name the formulas of simple binary compounds formed between non-metals and name ternary compounds using the IUPAC system.

15.0 Relate the formation of ionic and covalent bonds to an atom's position on the periodic table.

Unit B: Concepts of Matter

1.0 Define and apply the concept of a mole.

2.0 Solve conversion problems involving grams, atoms, molecules, litres, and moles.

3.0 Define and apply the concept of conservation of mass.

4.0 Balance equations and solve problems involving stoichiometric calculations.

5.0 Identify a given equation as either endothermic or exothermic.

Unit C: Organic Chemistry

1.0 Describe how carbon forms single, double, and triple bonds.

2.0 Identify and distinguish among alkanes, alkenes and alkynes.

3.0 Name non-branched aliphatic hydrocarbons to eight carbons.

4.0 Name and identify structural isomers of saturated aliphatic hydrocarbons.

5.0 Discuss common use of aliphatic hydrocarbons by relating use to structure, bonding, and physical properties of the hydrocarbons.

6.0 Differentiate between aliphatic and aromatic hydrocarbon structures.

7.0 Identify the functional groups for an alcohol, acid, and ester.

8.0 Be able to name an alcohol, acid or ester from a single structural formula, and list some properties and uses.

9.0 Write reactions for the combustion of an alcohol and the synthesis of an ester.

Unit D: Gases

1.0 Differentiate among gases, liquids and solids using such physical properties as density, shape, volume, melting and boiling points.

2.0 Apply the kinetic molecular theory to explain changes in volume, number of molecules and temperature on the pressure exerted by a gas.

3.0 Describe the operation of a Torricelli barometer.

4.0 Change degrees Celsius to Kelvin and vice versa.

5.0 Interpret the graph relationships of Boyle's and Charles' Law.

6.0 Solve problems using Boyle's Law, Charles' Law, and $P_1V_1/T_1 = P_2V_2/T_2$.

7.0 Solve gas problems involving partial pressures in the collection of gases over water.

Unit E: Solutions

1.0 Describe how factors such as temperature and intermolecular forces affect the vapour pressure of a liquid.

2.0 Explain the relationship between the vapour pressure and the boiling point of a liquid.

3.0 Identify the parts of a homogeneous solution; e.g., solute, solvent.

4.0 Describe the differences between a pure liquid and a solution in terms of physical properties such as vapour pressure, boiling point and freezing point.

5.0 Prepare solutions of known molar concentrations.

6.0 Solve problems involving preparation of solutions and dilution of same with water or like substances.

7.0 Describe the effect of the dissolving of electrolytes on the conductivity of a solution.

8.0 Write ionic equations showing the dissolving of ionic solids in water.

9.0 Know the formula and names of the following ions: SO_4^{2-}, NO_3^-, CO_3^{2-}, PO_4^{3-}, OH^-, HCO_3^-, HSO_4^-, SO_3^{2-}, MnO_4^-, NH_4^+, CrO_4^{2-}, $Cr_2O_7^{2-}$.

10.0 Know the ions with universal solubility in water: nitrates and acetates; ammonium, hydrogen, alkalies.

10.1 Use a solubility chart to predict precipitate formations between ions.

11.0 Write overall and net ionic equations showing the formation of precipitates from a mixing of ionic solutions.

OPTION UNITS

Unit: Chemistry of Photography

1.0 Describe the reactions that produce silver halides.

1.1 Observe and describe what happens when silver halides are exposed to light.

2.0 Describe the chemical reactions applicable to developing films and paper with regard to:
- developer reactions;
- stopping bath reactions;
- fixing bath reactions.

3.0 Develop a roll of film (black or white - 35 mm or larger).

3.1 Make a contact print from that film.

4.0 Relate camera controls to proper exposure; sharp image.

5.0 Describe the theory of producing a colour image.

6.0 Develop a black and white enlargement.

7.0 Relate each ingredient within a developer and/or fixer to its chemical function.

Unit: Energy

1.0 Differentiate among the common fossil fuels as to composition, source and use.

2.0 Differentiate between the common energy and power units.

3.0 Differentiate between ordinary gasoline and gasohol as to composition, octane rating, and energy content.

4.0 Compare processes for the production of methane, methanol, and ethanol from biomass.

5.0 Describe how hydrogen could be produced and used as a fuel.

6.0 Compare the advantages and disadvantages of using gasohol, methane, methanol, ethanol, natural gas, propane, hydrogen as a transportation fuel.

7.0 Describe the operation of a fuel cell.

8.0 Compare the advantages and disadvantages of using electricity as an alternative to a liquid fuel in the transportation sector.

9.0 Compare the production and use of alternative fuels quantitatively.

Unit: Polymers

1.0 State that polymers (plastics) are made up of monomers and describe examples.

2.0 Describe how polymers are made: addition polymers and condensation polymers; e.g., polyethylene, polyesters, and nylon.

3.0 Describe the manufacturing processes and uses of polymers: especially those of polyethylene, PVC, nylon, and polyesters.

4.0 Compare the advantages and disadvantages of producing polymers.

Extension

5.0 Identify the signficant elements of an issue as well as their logical relationships, the implications of the issue, and the trade-offs, both technological and economic, which must be made to resolve it.

5.1 Evaluate alternative solutions.

Unit: The Chemistry of Food Additives

1.0 Identify by name and general structure, some examples of the following food groups: carbohydrates, proteins, vitamins, and minerals.

2.0 Identify factors which influence consumer selection of food products.

3.0 Define the term, food additives.

4.0 Use reference material to identify additives and their uses.

5.0 Determine through experimentation and research the function of selected food additives.

6.0 Describe and/or apply techniques used in food technology.

6.1 Test foods for the presence of specific additives.
6.2 Identify methods for determining additive safety.

7.0 Identify the advantages and disadvantages that might arise from the use of food additives in foods.

8.0 Use the materials in this unit to evaluate the use of additives in food products.

Unit: Chemicals as Drugs

1.0 Differentiate among the major drug classifications and become familiar with names and terms related to the classifications.

2.0 Identify the normal biochemistry of a drug target area in the body and indicate the changes produced by the drug.

3.0 Describe the effects of interactions of drugs (including synergistic effects).

4.0 Prepare and/or compare different types of over-the-counter drugs.

5.0 Examine the influence of drugs on an individual's lifestyle.

OBJECTIVES FOR CHEMISTRY 300

CORE UNITS

Unit A: Electronic Structure, Bonding, Periodic Table

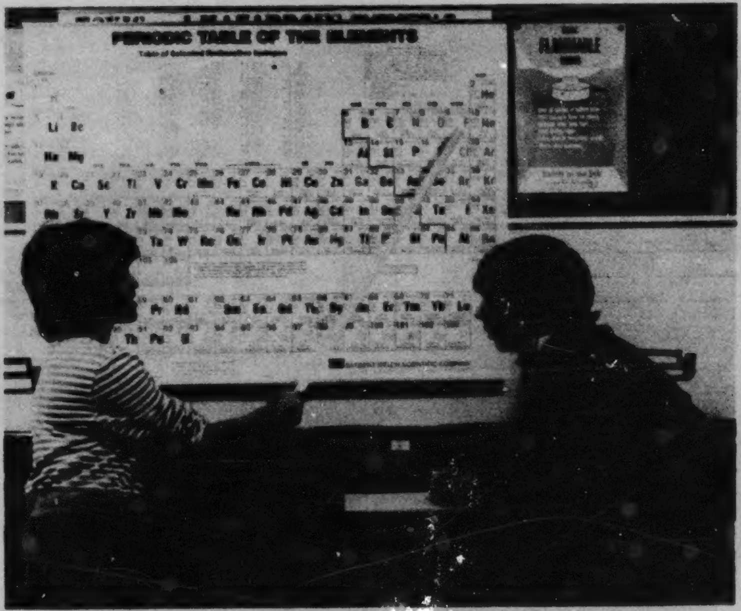
1.0 Calculate the wave length or frequency using $\lambda = c/\nu$ or $\nu = c/\lambda$.

2.0 Identify the parts of the electromagnetic spectrum in terms of their comparative wave lengths, frequencies, and energies.

3.0 Calculate the energy of light using $E = h\nu$.

4.0 Relate electron transition between energy levels to line spectra produced by a flame or gas discharge tube.

5.0 Explain the quantum model of the atom in terms of:
- energy levels;
- principal quantum number;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- orbitals as a region of probability s, p, d, f.

6.0 Write out electron configuration to atomic number 18, Argon, and relate to the periodic table.

7.0 Explain how ionization energy is related to electron configuration and the periodic table.

8.0 Use ionization energy or electronic configuration to predict the valence of an atom.

9.0 Define and explain the formation of ionic, covalent, and multiple bonds.

10.0 Draw electron dot diagrams of ionic, covalent, and co-ordinate covalent (dative) bonded molecules and ions.

11.0 Relate the organization of the periodic table to ionization energy, reactivity, atomic radius, and electronegativity.

12.0 Use electronegativity values to predict the type of bond (ionic or covalent) formed between two elements, and the polarity of two atom molecules.

Unit B: Reaction Rate and Chemical Equilibrium

1.0 Define rate in terms of some quantity per unit of time.

2.0 Explain, using molecular concepts, how the nature of reactants, changes in concentration, temperature, and the addition of a catalyst affect the rate of reaction.

3.0 Explain why a reaction takes place in a series of steps and the slowest step is the rate determining step.

4.0 Describe, using molecular concepts, how changes in surface area affect the rate of heterogeneous reaction.

5.0 Apply collision theory and the role of activation energy in determining rate of reaction.

6.0 Draw and interpret potential energy diagrams for endothermic and exothermic reactions.

7.0 Explain chemical equilibrium in terms of equal rates of forward and reverse reaction.

8.0 Apply Le Chatelier's Principle to predict how an equilibrium system will respond to changes in concentration.

Unit C: Ionic Equilibria - Acids and Bases

1.0 Differentiate between electrolytes and non-electrolytes and between strong and weak electrolytes.

2.0 Identify an acid, base and a salt from their respective formulae and properties.

3.0 Differentiate between strong and weak acids and strong and weak bases. Identify them in common substances found in the school or home.

4.0 Know the names and formulas of common acids and bases such as: HCl, CH_3COOH, HNC_3, H_2SO_4, $NaOH$, KOH, NH_4OH.

5.0 Define the process of neutralization.

6.0 Solve problems involving acid-base neutralization.

7.0 Define pH and relate the relative acidity to the pH of common substances.

8.0 Solve problems using pH.

9.0 Identify acids and bases using the Bronsted-Lowry definition.

10.0 Describe the nature of acid-base reactions as an equilibrium.

    10.1 Use Le Chatelier's Principle to predict the effect of changes in concentration or the addition of a common ion on an acid-base equilibrium.

11.0 Explain how an indicator works in an acid-base equilibrium.

12.0 Write mass action expressions for acid-base reactions.

13.0 Differentiate between the magnitudes of various K_a's and strengths of acids.

14.0 Solve problems in ionic equilibria using K_a's.

Unit D: Solubility

1.0 Explain solubility in terms of a dynamic equilibrium.

2.0 Describe the effect of temperature on the solubility of a solid in a liquid; and the solubility of a gas in a liquid.

3.0 Write Ksp expressions, given an equation.

4.0 Calculate the solubility in water of any singly ionized compound from its Ksp.

5.0 Calculate the Ksp from the solubility of a singly ionized compound (one-to-one ratio).

6.0 Make quantitative predictions based on calculations as to whether two solutions of known concentrations and volumes will or will not form a precipitate when mixed.

Unit E: Oxidation-Reduction

1.0 Draw and label a functioning electrochemical cell given two substances for electrodes.

2.0 Identify a reaction as an oxidation-reduction equation by determining electron transfer.

3.0 Identify the substance oxidized, substance reduced, the oxidizing agent, and the reducing agent in any oxidation-reduction reaction.

4.0 Use data from experiments to rank various substances in ability to compete for electrons.

5.0 Predict the ability of reactions to occur using a table of reduction potentials.

6.0 Balance oxidation-reduction equations using oxidation numbers or a table of half reactions.

7.0 Draw and label an electrolysis cell.

8.0 Solve problems using Faraday's laws of electrolysis.

9.0 Apply oxidation-reduction theory to lab-related activities.

OPTION UNITS

Unit: Analytical Chemistry

1.0 Test unknown solutions by means of:
    1.1 Qualitative Analysis: Cations
    1.2 Qualitative Analysis: Anions
    1.3 Quantitative Analysis
    1.4 Colorimetric Analysis
    1.5 Gravimetric Analysis

2.0 Relate analytical chemistry to application in technology, water management and other potential careers.

Unit: Metallurgy

1.0 Describe how some of the common metals are extracted from ore.

2.0 Describe the process of reducing metals from their oxides.

3.0 State how metals are refined.

4.0 Describe the process of metal corrosion.

5.0 State methods of preventing corrosion.

Extension

6.0 Describe the trade-offs necessitated by the process of making metals from raw materials.

    6.1 Describe technological means for decreasing negative environmental effects.

Unit: Consumer Chemistry

1.0 Describe how common chemicals can be combined to make consumer products.
    1.1 Describe the formation of soap.
    1.2 Describe the formation of detergents.
    1.3 Prepare various cosmetics.

2.0 Identify the properties of soaps and detergents.

3.0 Compare chemical products on a cost-effective basis.

- 3.1 Compare and rate soaps and detergents on a cost-effective basis.
- 3.2 Rate cosmetics according to pre-selected criteria.

4.0 Describe the components of food in qualitative and quantitative terms.

- 4.1 Analyze foods qualitatively for some of their components.
- 4.2 Analyze foods quantitatively for their components.
- 4.3 Compare food products on a cost-effective basis.

5.0 Analyze food for some selected food additives.

6.0 Analyze and compare various analgesics and antacids on a cost-effective basis.

Unit: Environmental Chemistry

Part I: Water Chemistry

1.0 Recognize the quality and the finiteness of the supply of drinking water, its distribution around the world, and the need to conserve.

2.0 Describe the interrelationships and balance within an ecological cycle and how man has intervened in this cycle.

3.0 Describe temporary and permanent hardness in water and how it can be measured and controlled by water softening.

4.0 Differentiate between a soap and a detergent and describe the action of detergency.

5.0 Describe the effect of phosphates on the phosphorous cycle and how their presence can lead to eutrophication.

6.0 Compare the advantages and disadvantages of alternatives to phosphates in detergents.

7.0 Measure biochemical oxygen demand (BOD).

- 7.1 Describe ways of lowering BOD in waste waters.

8.0 Describe primary, secondary, and tertiary sewage treatment.

9.0 Compare the role of sewage lagoons, anaerobic bacteria, activated sludge process, chlorination and desalination in water treatment.

10.0 Describe other pollutants and their effect on the environment and on people.

11.0 Compare the pros and cons of attempting to remove completely pollutants such as pesticides and PCB's from the environment.

Extension

12.0 Identify the significant elements and implications of industrially producing a new product upon the environment and economy of a town. Significant elements include alternative scientific-technological means for removing pollutants and their costs.

- . Identify relationships among the elements of an issue and their relative importance.
- . Distinguish among facts, opinions, beliefs and value judgements used in reaching a decision.

- Evaluate and present information about the issue of new, industrial production and its effect upon the environment and the people.

Part II: Air Chemistry

1.0 Identify sources of acid rain and smog (e.g., SO_2 and NO_2).
  1.1 Describe the chemical mechanisms whereby they become acid rain.
  1.2 Describe the effects of acid rain and smog on human beings, animals, plants, steel, and stone.

2.0 Compare methods of limiting the concentration of acid rain and smog in the environment and their costs.

3.0 Describe the role of tetraethyl lead in gasoline, its effect on the environment and alternatives to its use.

  3.1 Describe the operation of a catalytic converter in reducing air pollution and the reasons for removing lead from gasoline. Compare the effectiveness of the catalytic converter in removing pollutants to other alternatives.

Unit: Chemistry of Food Production

Part I: Soils and Fertilizers

1.0 Describe the component parts and properties of soils.

2.0 Describe the general principles of soil formation and distribution in Manitoba.

3.0 Relate plant growth and plant nutrition to dependency on such properties as:
  3.1 the essential nutrients and the ways whereby the nutrients are absorbed by the plants;
  3.2 solubility, ion exchange and water capacity of soils;
  3.3 pH of soils (acidity- basicity) and salinity.

4.0 Describe how to correct for alkalinity, acidity and salinity of soils.

5.0 Classify soils and relate the classes to potential uses and limitations.

6.0 Identify ways in which soil quality is degraded and methods whereby soil degradation can be prevented.

7.0 Compare the advantages and disadvantages of organic and non-organic fertilizers relative to plant growth and maintenance of land.

Part II: Insect and Weed Control

1.0 Differentiate among the various classes of chemicals used to control insects.
  1.1 Identify and compare some natural chemicals used in defense and communication.
  1.2 Identify and compare some broad-spectrum insecticides in terms of:
    - toxicity;
    - residual toxicity;
    - biomagnification or concentration in the food chain;
    - method of action.

2.0 Describe the susceptible periods in the life cycle of an insect such as the grasshopper or mosquito.

3.0 Compare the advantages and disadvantages of various methods of controlling insects:
   - chemical controls (pesticides, pheromones, repellents, juvenile hormones);
   - genetic controls (sterilization);
   - insect-resistant crop varieties;
   - biological agents (parasites, microbial agents)
   - integrated control methods.

Weed Control

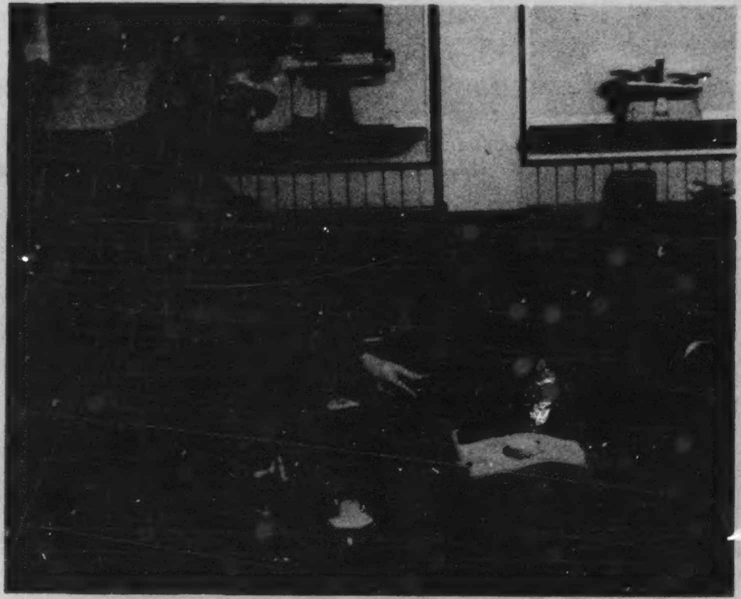
1.0 Classify common herbicides and describe their general method of operation.

2.0 Compare the advantages and disadvantages of different methods of weed control.

CURRICULUM ADOPTION AND IMPLEMENTATION

Curriculum adoption is the formal introduction of the curriculum guide, the purchase of new materials and the provision of orientation sessions. Curricululm adoption is distinguished from curriculum implementation which is a long-term process of several stages which requires continuous commitment and action and which results in measurable differences in classroom practices and student behaviour. Adoption of the new chemistry curriculum is expected to begin September, 1984, soon after the distribution of guides and the scheduling of in-service sessions. Implementation will begin at the same time and is expected to take place in stages over a three-year period.

The purchase of new texts is normally a part of the adoption procedure which precedes the implementation phase. For Chemistry 200 and 300, however, the purchase of new materials may not be necessary at the beginning, but will not, in any case, take place until the second stage of implementation, after teachers have had an opportunity to assess the merits of new materials and test them in classroom practice.



THE ROLE OF THE TEACHER

Two implementation stages are recommended for the chemistry curriculum. In the first, teachers should become familiar with the rationale and general design of the program, the objectives, and some of the general implications of the change.

Teachers should examine and try using in class some of the support materials to become familiar with their strengths and weaknesses, the ways which they can be used and combined, and the changes that may be necessary in laboratory activities. Working with the support materials will give teachers an opportunity to decide whether changes in teaching methods will be necessary.

In the second, teachers should begin full-scale implementation of the new program, combining new materials with old texts, introducing new modules and laboratory activities and determining organizational needs and key activities for new topics. Some of the new units such as Consumer Chemistry and Chemistry of Photography will likely involve organizational changes. The unit design charts will provide more specific information regarding such changes.

Possible Time-Line

1984-85 Curriculum Adoption (familiarization with the objectives and the guide)
Development of a general plan for implementation
Review of new materials; attempt of ideas from alternate core texts
Attempt of one or more science, technology society units using sample materials as teacher resources
Determination of new laboratory activities and equipment requirements

1985-86 Full-Scale Curriculum Implementation
Introduction of Science, Technology, Society units
Definition of needs for alternate core texts and modules
Purchase of the above

THE ROLE OF THE ADMINISTRATOR

Administrators may wish to familiarize themselves with the new curriculum and consider its implications for the purchase of new materials, whether they be alternate core texts or support materials for the option units.

Administrators can support the process of implementation by:

1) allowing time for the development of local expertise on alternate texts and options during the first year of implementation;
2) developing a plan for implementation based on specific needs; for example, the development of a local option to meet those needs and the science, technology, society objective (development could involve the cooperative effort of two or more schools);
3) providing a small emergency fund for obtaining simple, inexpensive laboratory materials locally (some parts of the Consumer Chemistry unit for example).

	CHEMISTRY 200 CORE					CHEMISTRY 300 CORE				
	PERIODIC TABLE & ELEMENTS	CONCEPTS OF MATTER	ORGANIC CHEMISTRY	GASES	SOLUTIONS	STRUCTURE, BONDING, PERIODIC TABLE	REACTION RATE EQUILIBRIUM	ACIDS AND BASES	SOLUBILITY	OXIDATION-REDUCTION
CONCEPTS	. Fundamental particles of atoms . Grouping of elements and Periodic Table . Elements and compounds, atoms and molecules	. Balanced equations . The mole and quantitative relationships . Energy changes in chemical reactions	. Carbon bonds . Saturated and unsaturated series . Functional groups	. Comparative properties of gases, liquids and solids . Pressure, temperature and volume relationships . Partial pressures	. Kinetic energy--molecular theory and phase relationships . Concentrations of solutions . Ionic equations . Precipitate formation	. Energy states and atoms . Quantum model . Bond formation . Energy, bonding, and the periodic table . Electron dot notation	. Factors affecting reaction rate and equilibrium . Le Chatelier's Principle	.Properties and definition .ID and strength .Quantitative calculations and equilibrium	. Factors affecting solubility . Quantitative calculations and equilibrium	. Electrochemical cell, electron transfer and oxidation-reduction . Balance equations . Faraday's Laws
SKILLS	. Predict charge and bond type using periodic table	. Determine mass . Measure volumes accurately . Determine, uncertainty and precision . Use scientific notation		. Interpret graph relationships	. Make solutions of required molarity	. Predict valence . Use electronegativity values to predict bond type		. Titration . Solve problems using pH	. Predict solubility using Ksp	. Use data to rank substances

program overview

PROGRAM IMPLEMENTATION

The Chemistry 200 and 300 program is no longer the text but the curriculum objectives stated in the first section of the guide. Teachers should refer to the section for information on the expectations for the course and to the unit design charts for teaching ideas and suggested materials. Materials will vary in their ability to support specific objectives.

TIME ALLOTMENTS

Time allotments for Chemistry 200 and 300 are 110 hours per course. The core portion of the program requires 75-80% of the available time. The remaining 20-25% is to be devoted to the option units. Two science, technology, society units are to be completed per grade in that time.

STRUCTURE OF THE PROGRAM

Chemistry 200 contains five core units and two option units. In general, the sequence of the core units suggested in the guide should be followed, with the possible exception of Organic Chemistry which can be delayed within the sequence. Units from the option area could be completed at the end of the core, or some units, such as Polymers and Chemistry of Food Additives, could readily be attempted after the Organic Chemistry unit.

Likewise, Chemistry 300 consists of five core units and two units from the option area. The sequence of the core units should be followed as given. Depending on the choice of topics from the designed options, a topic can be related to specific core units or may be integrated into a number of units. Metallurgy should be related to Oxidation-Reduction and Analytical Chemistry could be integrated with Solubility.

The core objectives for both Chemistry 200 and 300 are prescriptive and attempt to provide the necessary learning outcomes for students who intend to continue their studies in chemistry or related fields. For both, the sequencing of specific objectives within each unit can be modified according to materials used, the background of students or other variables.

The core portion of the program should be relatively familiar to chemistry teachers, except, perhaps, for Organic Chemistry. The option portion of the program which deals with the relationship of science, technology, and society may contain relatively familiar content such as analytical chemistry or unfamiliar content such as agriculture or energy. It may also contain familiar techniques such as testing for cations or such unfamiliar techniques as simulations (dealing with the resolution of a pollution problem). Teachers should become familiar with the differences among the units and potential starting points in teaching a new unit. Piloting of the program indicated that there was sufficient time to develop both core and the options.

Flexibility to meet the varying needs and abilities of high school students is provided in the option units. There are five designed units, from which two must be chosen for completion. The units vary in complexity and in their emphases upon different aspects of the science, technology, and society goal. Modules have been identified to support these units which also offer a variety of approach-

GENERAL TOPICAL DESIGN FOR CHEMISTRY 200

Energy

- Hydrogen, gasohol and other sources of energy
- Comparison of alternative fuels

Chemicals as Drugs

- Classification: over-the-counter, prescription, psychotropic
- Biochemistry: physiological implications--use and abuse
- Legal implications

Local Option

CORE

Periodic Table and Elements

- Atomic particles
- Elements, compounds, formulae
- Chemical families, periodicity
- Bonding

Concepts of Matter

- Moles and conversion problems
- Balanced equations

Organic Chemistry

- Simple carbon bonding
- Aliphatics, isomers
- Functional groups (alcohols, esters, acids)

Gases

- Properties
- Kinetic molecular theory
- Boyle's and Charles' law

Solutions

- Properties and preparation
- Ionic equations and solubility

Polymers

- Monomers, addition and condensation polymers
- Uses, production
- Advantages, disadvantages

Chemistry of Photography

- Chemical reactions; producing silver halides; fixing reactions
- Making prints
- Colour photos
- Camera controls

Chemistry of Food Additives

- Food Groups: structure and function
- Nature and role of additives
- Testing for selected additives
- Additives: pros and cons

# Teachers may wish to expand the section on food groups; however, they should make certain that students have not taken the nutrition unit in the Science 100 course.

GENERAL TOPICAL DESIGN FOR CHEMISTRY 300

Chemistry of Food Production

Part I
- Soil: nature, nutrients and plant growth
- Actions of fertilizers: advantages; disadvantages

Part II
- Chemical communication and defences (insects) psychotropic
- Controls (chemical; biological)-- pros and cons
- Weed control

Environmental Chemistry: Water

- Hard and soft water
- Effects of phosphates and nitrates; alternatives
- B.O.D.
- Water treatment
- Environmental effects of some pollutants; pros and cons; removal and limitations

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Environmental Chemistry: Air

- Sources and effects of pollutants
- Methods of limiting pollutants

CORE

Electronic Structure, Bonding, Periodic Table
- Energy levels
- Quantum model and electronic configuration
- Ionization energy, periodicity, and configuration
- Bonding and electronegativity
- Periodic table and atomic structure

Reaction Rate and Equilibrium
- Factors affecting reaction rate
- Equilibrium

Ionic Equilibria: Acids and Bases
- Electrolytes; acids, bases, and salts
- Neutralization problems
- pH, indicators
- Equilibrium, acid strength

Solubility
- Solubility calculations
- Quantitative predictions

Oxidation-Reduction
- Oxidation-reduction equations
- Prediction of reactions
- Faraday's laws

Local Option

Metallurgy

- Technology and science of extraction
- Corrosion and prevention
- Trade-offs associated with extraction of metals and human comfort

Analytical Chemistry

- Cation and Anion Analysis
- Volumetric Analysis
- Gravimetric Analysis
- Applications to careers

Consumer Chemistry

Part I
- Preparation and testing of soaps, detergents, and cosmetics

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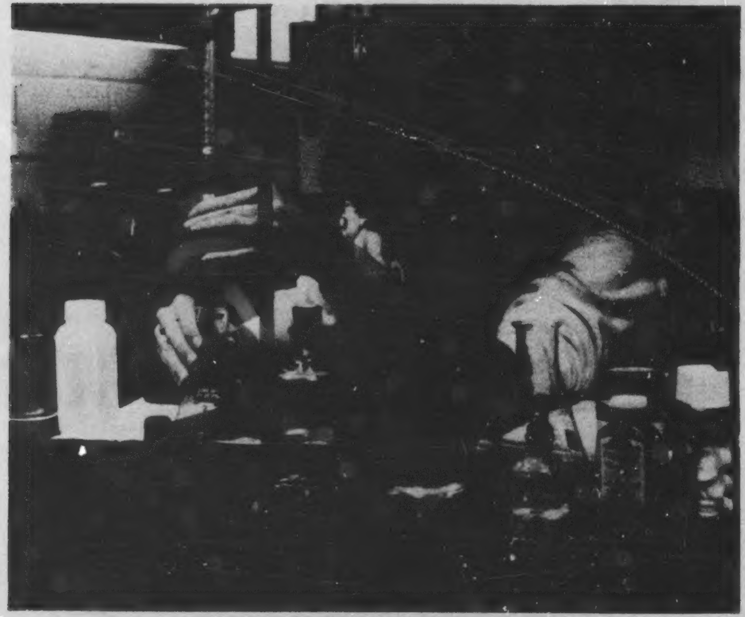
Part II
- Analysis and comparison of foods and food additives

Part III
- Comparisons among over-the-counter drugs

es and different levels of complexity. Schools can complete their own local option so long as it meets the science, technology, societal goal.

LABORATORY ACTIVITIES

Laboratory activities have an important role in any science program which attempts to reflect the nature of the discipline, that is, both process skills and concepts. A minimum of eight laboratory experiments for Chemistry 200 and eight for Chemistry 300 are required. The guide recommends a variety of activities from which teachers can choose. Other laboratory activities can be found in the laboratory manuals.



Although the Chemistry Committee has attempted to monitor the recommended experiments for safety, teachers should review specific labs and should also be guided by safety considerations in making their own choices.

Laboratory activities are designed to develop skills in observing, classifying, quantifying, formulating hypotheses, making operational definitions, controlling and manipulating variables, interpreting data, formulating models, inferring, predicting, experimenting and communicating. In addition to these science process skills, there are some specific skills that students should develop in the laboratory.

LABORATORY SKILLS

The student should be able to:

1. determine the mass of solids and liquids to the nearest centigram;
2. read a thermometer to the nearest half degree;
3. measure volumes accurately, avoiding parallx in the meniscus;
4. know that concentrated acid (> 1 molar) should be added to water, never the reverse;
5. understand that materials should never be placed directly on the balance pan;
6. make up a solution of required molarity of a solid in a liquid;
7. estimate quantities that are to be used and use only what is required;
8. titrate an unknown concentration of acid with a base, showing the proper use of a burette;
9. pipet any required amount of liquid, using proper techniques;
10. operate a bunsen burner properly;
11. place hot objects on a wire gauze or clay tri-

angle with clean tongs, taking care not to contaminate a sample;
12. fold filter paper properly and perform gravity filtration;
13. pick up and pour hot liquids from beakers;
14. maintain a clean work environment, taking care that materials are disposed of in proper containers;
15. Respect the purity of reagents by never laying a stopper directly on the bench and by never transferring reagents back to their original containers, once handled.

MATHEMATICAL SKILLS

There are some mathematical skills that students should develop as well, as a result of their work in the laboratory.

Students should be able to:

1. use a calculator, logarithm table, or slide rule to perform calculations that will involve multiplication, square roots, and exponents (powers of 10);
2. determine the results of calculations only to the precision warranted by the given data;
3. determine uncertainty;
4. use:
   a. the four basic operational skills--addition, subtraction, multiplication, division;
   b. scientific notation 10^x;
   c. basic operations on scientific notation;
   d. percent calculations by volume and by weight;
   e. density, ratio/proportion.
5. construct a properly labelled and drawn graph from given experimental data;
6. read and interpret data, given graphs (basic scale, non-logarithemic) and tables of data;
7. develop an ordered table of data.

MEASUREMENT, UNCERTAINTY, AND SIGNIFICANT FIGURES

There is some uncertainty in every measurement we make. Although some students may have been exposed to the concept of uncertainty before taking high school chemistry or physics, it is unlikely that they will be able to apply it to any degree. For example, when using calculators, they may provide answers based on the capacity of the instrument without any regard for the significance of all the numbers.

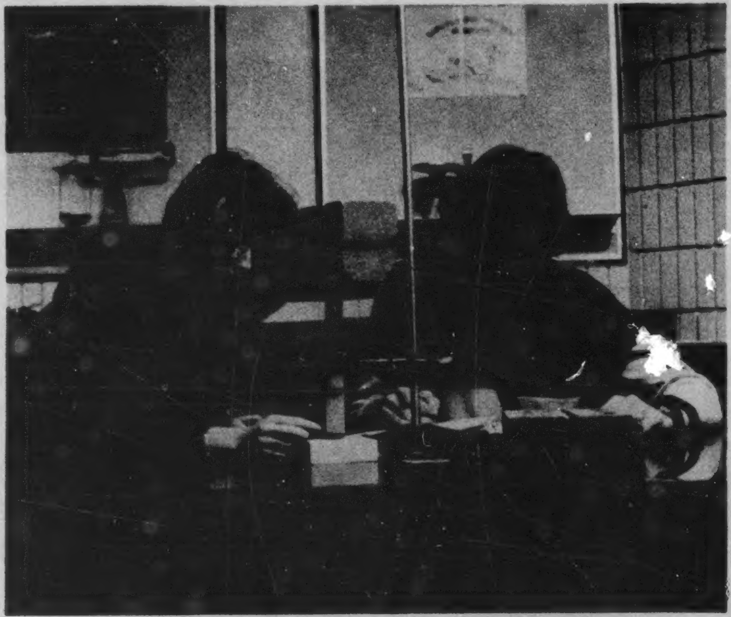
It is important that students learn about uncertainty and significant figures in measurement. It is equally important that they not become immersed or lost in a vast number of new concepts and rules related to measurement early in the course. These concepts are complex and potentially confusing and do after all constitute just one of many aspects of the program. These concepts should be introduced slowly and as the need arises; that is, in context, preferably through laboratory activities. They should be developed over time as a result of consistent, continual application. Only then can students be assured of developing both an understanding of the importance of the concepts and the ability to use them.

In order to provide some direction relative to the end-of-year expectations concerning uncertainty, the following student objectives are provided.

The student should be able to:

. distinguish between precision and accuracy in measurements;

- estimate and express the amount of uncertainty in a measurement (e.g., 5.26 ± 0.02 grams), and use significant figures (certain figures plus the first uncertain figure);
- state the number of significant figures from an exponential form and write exponential forms from a number;
- apply the correct rule in rounding off numbers to the correct significant digit;
- apply the concept of significant figures in derived quantities (A derived quantity can have only as many significant figures as the least precise quantity from which it is calculated. (DO NOT USE PERCENTAGE UNCERTAINTY.).



At the end of this implementation section is information on laboratory safety.

SUPPORT MATERIALS

The purchase of a great number of new materials is not necessary to implement the new program. It is possible to use the texts currently in use to teach core for both grades 11 and 12 and the option, Polymers. Additional options can be taught using modules; for example, for teaching the Chemistry of Photography in grade 11 and Metallurgy and Analytical Chemistry in grade 12. This is the simplest and least expensive scheme.

Another possibility is to use ALCHEM 10-20 or Chemistry for Today to teach grade 11 core and materials presently in use to teach grade 12 core. The required options in both grades can be taught with another text, either Chemistry for Changing Times or Applied Chemistry.

There are a number of other possible combinations as the correlation charts of materials and topics indicate. Teachers should become familiar with these possibilities during the first stage of implementation. Single copies of materials can be obtained and tested at that time. A limited number of samples are available in the Department of Education Library.

EVALUATION

Evaluation of student achievement and program effectiveness must be an integral, on-going part of the teaching-learning process. Evaluation should provide information regarding:

RELATIONSHIP BETWEEN SUPPORT MATERIALS AND CORE OR OPTIONS

Textual Materials	Core	Chemistry 200 Options					Chemistry 300 Options					
						FOOD	Envronmn.			FOOD		
		POLY	ENERGY	PHOTO	DRUGS	ADD.	WATER/	AIR	METAL	PROD	ANAL	CONS
Core Texts												
1) ALCHEM 10 and 20 (Chemistry 200 only)	#											
2) Chemistry Today (2nd ed.) (Chemistry 200 only)	#	P			P	P						
3) Chemistry: Experiments and Principles	#	P	P									
4) Chemistry: Experimental Foundations (3rd ed.)	#	P					P	P				
5) Chemistry: A Modern Course	#	P										
Laboratory Manuals for Core												
1) Chemistry Today: Laboratory Manual (2nd ed.)	#											
2) Chemistry: Experimental Foundations Laboratory Manual (3rd ed.)	#											
3) Chemistry: Experiments and Principles Laboratory Manual	#											
Texts Supporting Options Only												
1) Chemistry for Changing Times		#	P		#	#	#	#	P	#		#
2) Applied Chemistry		#	#		#	#	P	P		#		P
Modules												
1) IAC: Form and Function		#	P		P					P		

P - Represents a partial treatment of the option. To develop the unit using these particular materials, additional modules or articles will be needed. See the unit design chart for specific recommendations.
# - Specific information about materials is found in Appendix A. Relatively complete coverage.

RELATIONSHIP BETWEEN SUPPORT MATERIALS AND CORE OR OPTIONS

Textual Materials	Core	Chemistry 200 Options					Chemistry 300 Options					
							Environmental			FOOD		
		POLY	ENERGY	PHOTO	DRUGS	FOOD	WATER/AIR		METAL	PROD	ANAL	CONS
2) ALCHEM: Ethylene and Its Derivatives		#										
3) Chemistry of Photography				#								
4) Chemistry of Man and Molecules					#							
5) Chemistry of Common Substances (Lab Manual)					P	P					P	P
6) ALCHEM: Analytical Chemistry											#	
7) ALCHEM: Metallurgy and Corrosion									#			
8) Chemistry of Metallurgy									#			
9) Water, Chemistry and Ecology							#					
10) IAC: The Delicate Balance							#	#		P		
11) Consumer Science: Text and Laboratory Manual					#	#					#	#
12) LAP: The Chemistry of Soaps, Detergents and Cosmetics#												P
13) LAP: The Chemistry of Over-the-Counter Drugs					P							
14) LAP: The Chemistry of Food Additives						P						P
15) LAP: The Chemistry of Soils and Fertilizers										P		
16) LAP: The Chemistry of Food						P						P
17) LAP: The Chemistry of Beverages						P						P
18) The Amsyn Problem		P					P		P			
19) Laboratory Experiments for Foundations in Chemistry											P	
20) The Canadian Environment: Data Book on Energy and Environmental Problems			P				P	P	P	P		

LAP materials include ditto masters.

1. Diagnosis and remediation. The purpose of diagnosis is to identify a student's strengths and weaknesses. In the case of weaknesses, the cause of the problem may then be identified and appropriate remediation provided by the teacher.

2. Student growth in mathematical skills and understanding. This is an integral part of a developmental program. Because growth is continuous, evaluation must also be continuous. Teachers should assess a student's speed and accuracy, understanding of concepts and processes, ability in applying skills, and should use evaluation to encourage further student attainment in science.

3. Learning strategies. Results should be used to judge the effectiveness of the instructional process: program of experiences, materials of instruction and strategies of teaching.

4. Curriculum modification. Modifications should be on-going. Therefore, continuing feedback from the schools regarding the appropriateness of the objectives and the degree of implementaion of the current program is essential.

Testing is a vital component of evaluation. Tests may be structured to evaluate a specific concept, a series of inter-related concepts, or all the concepts found in a year's work. Classroom teachers should design and use cumulative tests so that students maintain proficiency in previously learned concepts and skills.

Evaluation is far more than paper and pencil testing. Teachers are reminded that evaluation of student achievement may take several additional forms such as daily observation, interviews or conferences with individual students, class discussions, student reports and projects related to definitive and open-ended problem-solving situations.[1]

SPECIAL NEEDS STUDENTS

It is not expected that there will be students in either Chemistry 200 or 300 whose needs will require any substantial modification of the program. Flexibility has been designed into the course to allow for the variation in students' abilities and needs. Teachers can take advantage of the variety of teaching materials and strategies suggested in the guidelines to meet those needs.

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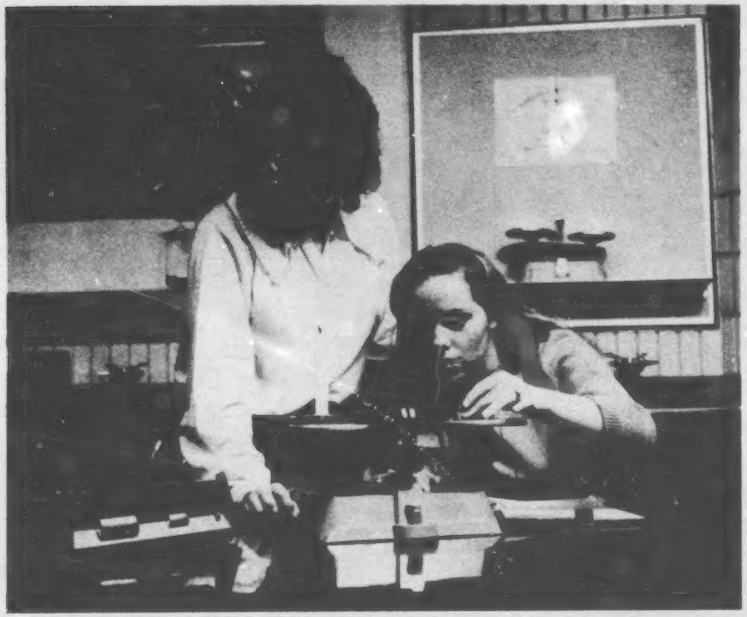
[1] Additional sources of information about evaluation can be found in William D. Hedges, Testing and Evaluation in the Secondary School (Belmont, CA: Wadsworth, 1966) and in Robert B. Sund and Anthony J. Richard, Behavioral Objectives and Evaluational Measures: Science and Mathematics (Columbus, OH: Charles E. Merrill, 1972).

Talented or Gifted Students

The Chemistry 200 and 300 outline identifies the minimum program for students. Scientifically gifted or talented students are likely to meet the course objectives in less time than others and may exhibit one or more of the following characteristics: 1) outstanding performance in most academic subjects; 2) prolific reading and the ability to understand scientific textbooks and articles; 3) preference for independent work with little teacher direction; 4) curiosity about abstract concepts; and 5) willingness to assume responsibility.



Teachers of the scientifically gifted are faced with a challenge to enrich the program with simulating and worthwhile activities. Suggestions for enrichment follow.

Stimulating Interest

- Provide a wide variety of materials and resources, such as the Science Teacher or Scientific American and other professional journals or magazines.
- Emphasize reading in chemistry.
- Encourage the pursuit of problems of interest to the student.
- Use science clubs to maximum advantage.
- Organize seminars at which students can present papers and special projects for ultimate submission to journals and newspapers.
- Encourage peer tutoring.
- Encourage participation in science fairs.

Providing Meaningful Activity

- Enrich the program rather than accelerate the students.
- Provide independent activities.
- Encourage entry in chemistry contests and competitions.
- Promote computer use in chemistry.
- Encourage students to apply their chemistry to fields such as engineering, meteorology, environmental science, and medicine.

Developing Additional Skills

- Provide higher level activities in problem solving, research, reading and writing skills than those required for regular programs.

- Emphasize the development of students' manipulative skills.

LABORATORY SAFETY

There is a safe way to perform all laboratory work. Just as defensive driving can prevent accidents on the road, adequate planning and understanding can prevent injury in the laboratory. "What should happen if. . .?" should be a question that guides the preparation and performance of all experiments. Answers to this question require an understanding of the hazards associated with the chemicals and equipment involved. Thus, a knowledge of the stability, reactivity, flammability and toxicity of chemicals being used dictates precautions to be taken. Such information might well form an introductory section to all written laboratory procedures.

The practice of safety in the chemical laboratory requires 1) the desire on the part of the individual to protect not only him- or herself but others as well, and 2) an understanding of the need to follow a set of rules. The former can be termed safety morale, the latter safety logic. Both are essential parts of accident prevention. Rules are usually established by laboratory supervision. However, communicating these rules should be initiated through discussion with all chemistry students.

The prevention of accidents in a laboratory is the responsibility of every individual who enters it. For the teacher, there is a special responsibility to reduce the potential for incidents that could give rise to injury. In this context, laboratory safety is a positive component of science teaching, and the importance of careful planning should be stressed throughout the program. As a result of this part of the chemistry program, students should develop safety conscious attitudes and behaviour. Since students tend to lack the instinctive feeling for investigative work that comes from the long-term familiarity with the laboratory, they must be taught how to handle materials which are potentially harmful to them.

SAFETY RULES

There should be only a limited number of rules for the laboratory, but they must be rigidly and impartially enforced. Willful non-compliance should result in dismissal or suspension from the laboratory.

There are many specific "do's" and "don'ts" related to specific situations and activities. For further guidance, teachers are referred to Safety in Science for Manitoba Science Teachers (1973) and Safety in Science (1982).[2] For additional information, teachers are also referred to the bibliography in each of these publications.

SAFE FACILITIES

The laboratory environment should not be hostile to the student and should be equipped with the appropriate safety devices and materials.

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[2] Copies were distributed to schools at the time of publication. Additional copies of the publication Safety in Science (1982) are available from Curriculum Services, Department of Education.

SAFETY RESPONSIBILITY

Each individual is responsible for performing his or her job safely. Untrained students or outsiders should not be permitted to work with chemicals except under adequate supervision. An instructor should be in the laboratory for the entire laboratory period.

Every teacher should:

1. Set a good example by:
   a) observing all rules and recommendations,
   b) wearing protective equipment where recommended,
   c) being enthusiastic about safety.
2. Be alert for unsafe conditions.
3. Take prompt corrective action for unsafe conditions.
4. Maintain discipline and enforce rules.
5. Prohibit the use of laboratory glassware for food or beverages - a dangerous practice.
6. Assume responsibility for visitors and require that they follow the same rules as students and other laboratory workers.
7. Carefully review all laboratory experiments for possible safety problems before the experiments are assigned to students.
8. Maintain a file of publications on laboratory safety, readily available to students, visitors, and others, and encourage its use.

School science laboratories can be as safe a place to teach and learn as any place in the school. This will only occur through the constant vigilance of teachers and students alike.

SAFETY NOTES IN THE GUIDE

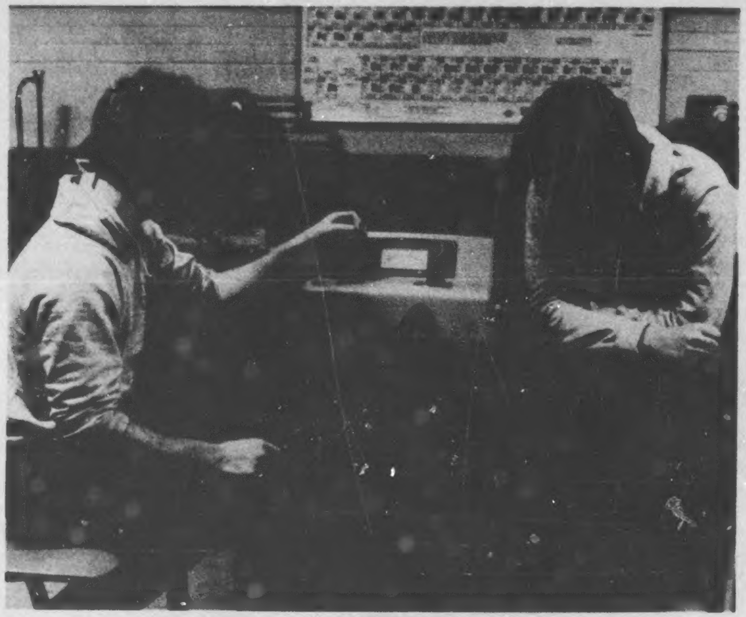
In the Activities Section of the unit design Charts, precautions are given for any recommended experiments that may require particular care in handling. It is suggested that the teacher refer to these cautionary notes often. In addition, the "Chemistry" section of Safety in Science (1982), available from the Department of Education, provides additional information about storage and handling of chemicals.

Summarizing some of the concerns regarding safety, the following notes may be helpful.

Precautions should be taken when working with volatile materials used frequently in esterification experiments. Under no circumstances should these materials be used near an open flame. Rather, they can be heated in a water bath which is kept hot by an electric hot plate in excellent working order. Warnings are not always given on the use of flames in such experiments. For example, some laboratory manuals suggest lighting ethanol fractions with a match despite the fact that volatile materials are used in other parts of the experiment.

Heating flammable liquids requires similar caution. The product of heating ethanol with acetic acid is ethyl acetate which is flammable. The direct source of heat for the reacting chemicals in a test tube should be a water bath.

Precautions should also be taken in working with concentrated acids such as sulfuric and glacial acetic acids. These are used in esterification experiments. Other volatile materials which are either used or produced in typical experiments and which pose distinct fire hazards are: ethyl acetate, ethyl butyrate, amyl acetate, butyl propionate, propyl acetate, propanol, and propyl formate. Side effects are possible with materials such as methanol, methyl salicylate, ethyl acetate, methyl butyrate, ethyl butyrate, amyl acetate and pentanol if ingested, inhaled or, in the case of methanol, absorbed through the skin. However, the threshold limit values (TLV's) for these materials are generally quite high so there has to be large concentrations in the air for extended periods of time to pose a hazard.



CAUTIONS CONCERNING CHEMICALS

Methanol - Highly hazardous if swallowed, moderately hazardous if absorbed through the skin; TLV (200 ppm); also a distinct fire hazard and explosion hazard

Potassium Dichromate - Highly hazardous, has been linked with cancer if inhaled or ingested

Potassium Chromate - Highly hazardous, has been linked to cancer if inhaled or ingested

Butyric Acid - Should be used in a hood as it leaves an ammonia smell

Ethyl Acetate - Moderately hazardous if inhaled or ingested; can be absorbed through the skin; also a dangerous fire hazard; avoid using near flames

Ethyl Butyrate - Dangerous fire hazard; toxic details unknown, but is irritating to membranes and narcotic in high concentrations; keep away from open flame

Methyl Salicylate - Highly hazardous if ingested

Methyl Butyrate - Moderately hazardous if ingested or inhaled; keep away from open flame

Amyl Acetate (n-pentyl acetate) - Moderately hazardous if ingested or inhaled, can cause headaches, burning of eyes, drowsiness; dangerous fire hazard; keep away from open flame

Pentanol - Highly hazardous if ingested or inhaled

Amyl Salicylate - Moderately hazardous

Ethyl Benzoate - Moderately toxic

Butyl Acetate - Moderately toxic, moderately hazardous for fires

Butanol - Moderately toxic, dangerous when exposed to flame

Butyl Propionate - Dangerous fire hazard

Propyl Acetate - Moderate health hazard; dangerous when exposed to flame

Propanol - Fire hazard

Barium compounds - Such as $BaNO_3$, $Ba(OH)_2$, BaO can be toxic; Low TLV values are reported in the literature

Carbon Tetrachloride (CCl_4) - Carcinogenic, should be replaced by TTE (trichlorotrifluorethane)

THE INTERNATIONAL SYSTEM OF UNITS (SI)

The metric system of measurement is used in all scientific studies. As a result of a treaty signed in 1875, metric conventions are established and modified when necessary by international agreement. From time to time, an international group, the General Conference of Weights and Measures, meets to ratify improvements in the metric system. Some aspects of the currently approved INTERNATIONAL SYSTEM OF UNITS (LE SYSTEME INTERNATIONAL D'UNITES, officially abbreviated SI) are summarized in this guide. This system is a modernization and simplification (fewer units are used than previously) of the old metric system, which developed from one proposed by the French Academy of Science in 1790. The International System of Units of Systeme International (SI) was adopted by the 11th General Conference of Weights and Measures in 1960. It is constructed from seven base units, each of which represents a physical quanitity (Table 1).[3]

TABLE I SI BASE UNITS

PHYSICAL QUANTITY	NAME OF UNIT	SYMBOL
1. Length	metre	m
2. Mass	kilogram	kg
3. Time	second	s
4. Temperature	kelvin	K
5. Amount of substance	mole	mol
6. Electric current	ampere	A
7. Luminous intensity	candela	cd

Of the seven units listed in Table 1, the first five are particularly useful in general chemistry. They are defined below:

1. The metre was redefined in 1960 to be equal to 1 650 763.73 wavelengths of a certain line in the orange-red region of the emission spectrum of krypton-86.

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[3] Additional sources of information are Science Teacher's Guide to Metrication, which is available from Curriculum Development and Implementation Branch, Department of Education and Metric Style Guide, Council of Ministers of Education, Toronto.

2. The kilogram represents the mass of a platinum-iridium block kept at the International Bureau of Weights and Measures at Sevres, France.

3. The second was redefined in 1967 as the duration of 9 192 631 770 periods of a certain line in the microwave spectrum of cesium-133.

4. The kelvin is 1/273.16 of the temperature interval between the absolute zero and the triple point of water.

5. The mole is the amount of substance which contains as many entities as there are atoms in exactly 0.012 kg of carbon-12.

PREFIXES USED WITH SI UNITS

Decimal fractions and multiples of SI units are designated by using the prefixes listed in Table II. Those which are most commonly used in general chemistry are underlined.

DERIVED UNITS

In the International System of Units, all physical quantities are represented by appropriate combinations of the base units listed in Table I. To choose a particularly simple example, the SI unit for volume, the cubic metre, represents the volume of a cube one metre on an edge. Again, in SI, the density of a substance can be expressed by dividing its mass in kilograms by its volume in cubic metres. A list of the derived units most frequently used in general chemistry is given in Table III.

TABLE II SI PREFIXES

FACTOR	PREFIX	SYMBOL	FACTOR	PREFIX	SYMBOL
10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	kilo	k	10^{-6}	micro	μ
10^{2}	hecto	h	10^{-9}	nano	n
10^{1}	deca	da	10^{-12}	pico	p
			10^{-15}	femto	f
			10^{-18}	atto	a

TABLE III SI DERIVED UNITS

PHYSICAL QUANTITY	NAME OF UNIT	SYMBOL	DEFINITION
Area	square metre	m^2	
Volume	cubic metre	m^3	
Density	kilogram per cubic metre	kg/m^3	
Force	newton	N	$kg \cdot m/s^2$
Pressure	pascal	Pa	N/m^2
Energy	joule	J	$kg \cdot m^2/s^2$
Electric charge	coulomb	C	$A \cdot s$
Electric potential difference	volt	V	$J/(A \cdot s)$

The newton and the joule are examples of SI units that are given special names. Some derived units are named in terms of base units; for example, the SI unit of volume is the cubic metre, m^3.

The use of certain units that are not a part of SI but are widely employed is sanctioned. The litre, for example, which is defined as the volume of 1 cubic decimetre (and hence is 1000 cm^3) and concentration (mol/L), may be used in addition to the official SI unit of volume, the cubic metre. Certain other units that are not a part of SI are to be retained for a limited time; the standard atmosphere (atm, a unit of pressure) falls into this category. The International Committee of Weights and Measures considers it preferable, in general, to avoid the use of certain other units that are outside the International System; the use of the calorie (cal, an energy unit) and the torr (760 torr = 1 atm) is therefore discouraged.

Most scientists have adopted SI units. Many scientific groups and agencies (for example, the National Bureau of Statistics) have recommended their use and have adopted them. The advantages of uniformity in usage among scientists of all nations are obvious. Strict adherence to the International System, however, poses a problem since the system eliminates some units that have previously been widely used. For example, chemists have commonly used the calorie (which is the amount of heat required to raise the temperature of 1 g of water from 14.5 degrees to 15.5 degrees Celsius) as a unit of energy. The International System incorporates the joule as the unit for all energy measurements, and the International Committee of Weights and Measures recommends that the use of the calorie be discontinued. Thermodynamic values, however, have been recorded almost exclusively in terms of calories and kilocalories in the past; therefore, one must be familiar with both units.

Perhaps the least familiar of these units to beginning chemistry students are the ones used to represent force, pressure, and energy.

The newton is defined as the force required to impart an accleration of one metre per second squared to a mass of one kilogram (recall that Newton's second law can be stated as: force = mass X acceleration).

The pascal is defined as the pressure exerted by a force of one newton acting on an area of one square metre (recall that pressure = force/area).

The joule is defined as the work done when a force of one newton (kg X m/s^2) acts through a distance of one metre (recall that work = force X distance).

Some Basic Conventions

The following items from the Metric Style Guide are recommended for teachers to follow in implementing the new Chemistry curriculum. These conventions should be followed in preparing supplementary materials and tests at the school level. The section number from the Metric Style Guide (1975) is cited in brackets.

"Symbols should be used in place of full names when units are used in conjunction with numerals." For example, 12.0 mol, not 12.0 moles. (342)

"Symbols are not pluralized." The symbol s stands for seconds. For example, 0.26 kg, not 0.26 kgs. (342)

"Symbol is not followed by a period (except at the end of a sentence)." For example, 14.2 g, not 14.2 g. (342)

"Symbols for prefixes are shown in lower case except for those that are greater than 'kilo'." For example, 20 km, not 20 Km.

"Symbols for units named after individuals show the first letter in upper case." For example, 101 kPa (kilopascals), 9.8 N (newtons) and 0.25 L (litres).

"Compound symbols formed by dividing units contain a solidus (/) to indicate the division." For example, 16.0 g/mol, not 10.0 g per mol. (342)

"If a compound unit involving division is spelled out, the word 'per' is used." For example, metres per second, not metres/second. (341)

"Only one prefix is applied to a unit at a time." For example, nm (nanometre) not mμm (millimicrometre).

"Decimal fractions are generally preferred to common fractions." For example, 0.5 m, 0.50 m, 0.500 m (depending upon the number of significant digits) rather than 1/2 m). (343)

"A zero is placed to the left of the decimal marker if there is no other digit to the left." For example, 0.56 kJ, not .56 kJ. (343)

"Abbreviations such as sq. cm., should be avoided; they differ from one langauge to another, but SI symbols, such as cm^2, are the same in all languages." (342)

Compound symbols formed by multiplying units contain a dot (raised or on the line) to indicate multiplication. For example, 120 N.m, not 120 N X m or 120 (Nm).

Multiplied units in the denominator of a compound unit should be bracketted. For example, 4.19 kJ (kg degrees Celsius), not 4.19 kJ/kg degrees Celsius. (523)

"The use of the comma to separate sets of three digits to the left (and now right) of the decimal point is now to be discontinued; a space is left where we used to put a comma." "If there are only four digits to the left or right of the decimal marker, the space is unnecessary except in a column with other numbers that show the space." For example, 56,384.29 becomes 56 384.29 and 3.14159 becomes 3.141 59. (333 and 343)

Metre and litre are spelled "re" in Canada and other English speaking countries except in the U.S. (122)

"The spelling, meter, is used for measuring devices such as thermometer." (122 and 513)

"To ensure that prefixes retain their identify when pronounced, the first syllable of each prefix is accented in particular, kilometre should be pronounced with the accent on the first syllable, as is our custom with units such as kilolitre, kilogram and kilowatt." "The accent on the second syllable generally applies to measuring devices, such as thermometer, speedometer, barometer and micrometer." (123)

"The word 'weight' should be avoided because of its ambiguity. The expression 'force of gravity' should be used (instead of 'weight')." Instead of using the word 'weigh' (when units of mass such as grams are obtained) the expression "find (or determine) the mass of" should be used. (532 and 242)

The micron and the angstrom are to be replaced by the micrometre and the nanometre respectively. (212)

"In Canada, the preferred spelling for the prefix meaning 10 times is 'deca' while in the U.S.A. and Australia it is 'deka.' The symbol is 'da' in all countries." (141)

The unit symbols of volume replacing the cc are the cm^3 (dry volume) and the mL (capacity) (1 cm^3 = 1 mL exactly). "It is suggested that to avoid confusion, 4 cm^2 be read as "four square centimetres in preference to "four centimetres squared." (222)

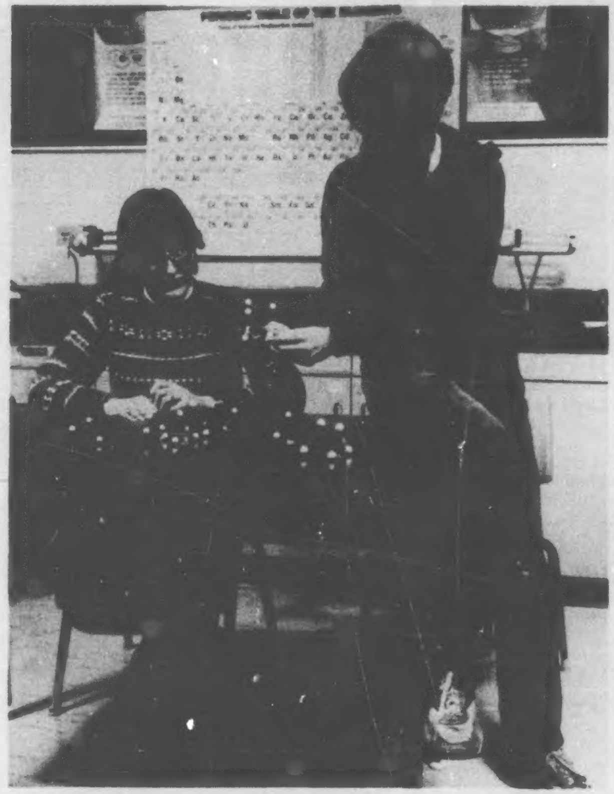
Five degrees Celsius means either a specific temperature or a temperature change. (Celsius degrees is not to be used.) (261)

"In general, a prefix should be chosen so that the numerical value lies between 0.1 and 1000." (This rule eliminates the need for scientific notation in the majority of cases.) (343)

"A space is left between the last digit of a numeral and the first letter of a symbol." For example, 4.5 kg, not 4.5kg. An exception is for the expression of temperature in degrees Celsius where the degree sign occupies the space between the numerical value and the unit symbol; e.g., 25° C, not 25°C. (343)

NOMENCLATURE OF INORGANIC COMPOUNDS

In 1938, the International Union of Pure and Applied Chemistry (IUPAC) drafted a set of rules for naming inorganic compounds. Revised in the 1950's and published in 1960, these naming rules incorporated the system developed by an inorganic chemist, Alfred E. Stock, which uses roman numerals to designate the oxidation state of a compound. The Stock System had developed to systematize the old classical method, to drop the use of both trivial names such as vitriol, soda, muriatic acid, carbonate of lime, and prefixes that caused confusion when a cation or anion had more than one oxidation state. IUPAC rules do not use trivial names and discourage the use of the suffixes -ous and -ic. However, they do retain the use of -ate, -ite, -ide, hypo-, and per- for many well-known compounds. A brief summary of the IUPAC rules follows.



IONIC COMPOUNDS

The names of ionic compounds are derived from those of the ions of which they are composed. We shall first consider the nomenclature of individual ions and then the names of the compounds they form.

Positive Ions

Monatomic positive ions take the names of the metal from which they are derived:

Na^+	sodium	Ca^{2+}	calcium	Al^{3+}	aluminum

When a metal forms more than one ion, it is necessary to distinguish between these ions. The accepted practice today is to indicate the charge of the ion by a roman numeral in parentheses immediately following the name of the metal:

Fe^{2+}	iron(II)	Cu^+	copper(I)	Sn^{2+}	tin(II)
Fe^{3+}	iron(III)	Cu^{2+}	copper (II)	Sn^{4+}	tin(IV)

The only polyatomic cations to be considered here are:

NH_4+	ammonium	H_3O+	oxonium

Negative Ions

Monatomic negative ions are named by adding the suffix -ide to the stem of the name of the nonmetal from which they are derived:

N^{3-}	nitride	O^{2-}	oxide	F^-	fluoride
H^-	hydride				

BINARY COMPOUNDS OF THE NONMETALS

When a pair of nonmetals form only one compound, that compound may be named quite simply. The name of the element whose symbol appears first in the formula (the element of lower electronegativity) is written first. The second portion of the name is formed by adding the suffix -ide to the stem of the name of the second nonmetal. Examples include:

HCl	hydrogen chloride	H_2S	hydrogen sulfide

If more than one binary compound is formed by a pair of nonmetals, as is most often the case, the Greek prefixes, di = two, tri = three, tetra = four, penta = five, hexa = six, and so on, are used to designate the number of atoms in each element. The Stock System of naming the oxides is also acceptable under IUPAC rules. Thus, for the oxides of nitrogen, the following nomenclature is used.

Formula		Name
N_2O	dinitrogen oxide	nitrogen (I) oxide
NO	nitrogen oxide	nitrogen (II) oxide
N_2O_3	dinitrogen trioxide	nitrogen (III) oxide
NO_2	nitrogen oxide	nitrogen(IV) oxide
N_2O_4	dinitrogen tetroxide#	dimer of nitrogen (IV) oxide
N_2O_5	dinitrogen pentoxide#	nitrogen (V) oxide

# Note: In this case the a is dropped from the prefixes penta and tetra for euphony.

A great number of the best known binary compounds of the nonmetals have acquired common names which are widely and, in some cases, exclusively used.

These include:

H_2O	water	PH_3	phosphine
H_2O_2	hydrogen peroxide	AsH_3	arsine
NH_3	ammonia	NO	nitric oxide
N_2H_4	hydrazine	N_2O	nitrous oxide

OXYACIDS

HNO_3	nitric acid	$HClO_4$	perchloric acid
H_2CO_3	carbonic acid	HNO_2	nitrous acid
$HClO_3$	chloric acid	H_3PO_4	phosphoric acid
$HClO_2$	chlorous acid	H_2SO_4	sulfuric acid
H_3BO_3	boric acid	H_2SO_3	sulphurous acid
H_4SiO_4	silicic acid	$HClO$	hypochlorus acid

It is of interest to compare the names of these oxyacids to those of the coresponding oxyanions listed previously. Note that oxyanions whose names end in -ate are derived from acids whose names end in -ic. Compare for example:

CO_3^{2-}	carbonate	H_2CO_3	carbonic acid
ClO_4^-	perchlorate	$HClO_4$	perchloric acid

Oxyanions whose names end in -ite are derived from acids whose names end in -ous. Thus:

NO_2^-	nitrite	HNO_2	nitrous acid
ClO^-	hypochlorite	$HClO$	hypochlorous acid

The nomenclature of polyatomic anions is more complex. The names of some of the more common oxyanions are:

NO_3^-	nitrate	ClO_2^-	chlorite
MNO_4^-	permanganate	NO_2^-	nitrite
ClO^-	hypochlorite	CrO_4^{2-}	chromate
SO_4^{2-}	sulfate	CO_3^{2-}	carbonate
$Cr_2O_7^{2-}$	dichromate	SO_3^{2-}	sulfite
PO_4^{3-}	phosphate	OH^-	hydroxide
ClO_4^-	perchlorate	ClO_3^-	chlorate
SiO_4^{4-}	silicate		

Notice that when a nonmetal such as nitrogen or sulfur forms two different oxyanions, the suffix -ate is used with the anion containing the larger number of oxygen atoms:

NO_3^- SO_4^{2-}

The suffix -ite is used with the anion containing

NO_2^- SO_3^{2-}

With elements such as chlorine, which form more than two oxyanions, the prefixes per- (largest number of oxygen atoms) and hypo- (smallest number of oxygen atoms) are used as well.

Oxyanions that contain hydrogen as well as nonmetal and oxygen atoms are properly named as illustrated in the following examples:

HCO_3^-	hydrogen carbonate	HPO_4^{2-}	monohydrogen phosphate
HSO_4^-	hydrogen sulfate	$H_2PO_4^-$	dihydrogen phosphate

Compounds

The name of the positive ion is given first, followed by the name of the negative ion. Examples are:

$CaCl_2$	calcium chloride	$FeBr_2$	iron (II) bromide
$(NH_4)_2SO_4$	ammonium sulfate	$Fe(ClO_4)_3$	iron (III) perchlorate
$NaHCO_3$	sodium hydrogen carbonate		

In practice, compounds containing metal atoms, regardless of the type of bonding involved, are ordinarily named as if they were ionic. For example, the compounds

$AlCl_3$ and $SnCl_4$

in both of which the bonding is primarily covalent, are named as follows:

$AlCl_3$	aluminum chloride	$SnCl_4$	tin(IV) chloride

THE IUPAC SYSTEM FOR ALKANES

1. The longest continuous chain of carbon atoms is selected as the basis for the name. The ending is -ane.

2. The carbon atoms in this chain are numbered from the end which gives the smallest possible number to the substituent encountered first.

3. The choice among chains of equal length is made in favour of the most highly substituted one.

4. Substituents are located by the number of the carbon atom to which they are attached in the basic chain. Branching alkyl groups are named according to the alkyl radical names, and their sequence in naming follows alphabetical order. (For convenience, substituents may be arranged in order of increasing molecular weight or complexity of number on the chain.)

5. When branching occurs at an equal distance from either end of the longest chain, the name that gives the lowest number at the first point of difference is chosen.

6. When two or more of the same substituent occur, the number of them must be indicated by the appropriate prefix di-, tri-, tetra-, etc., and the location of each on the main chain is indicated by number. These prefixes are ignored for purposes of alphabetical ordering unless they occur in a compound radical. The designations n-, sec-, and t- are also ignored; however, iso- and neo- are not.

7. The number locating the substituents are placed immediately before the names of the respective substituents, and hyphens are placed before and after the numbers. When two or more numbers occur together, commas are placed between them.

8. The name of the alkane results from placing the combination of numbers and substituent names as a prefix to the basic hydrocarbon chain. The whole is written as one word.

Radicals

1. The carbon by which the radical is attached to the rest of the molecule is numbered one.

2. The radical is named strictly according to the rules used for naming alkanes.

chemistry 200 (core)

CHEMISTRY 200 TIME: 15 hours

UNIT A: Introduction to the Periodic Table and the Elements

RATIONALE: This unit provides general background which is necessary for further study of chemistry.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Describe the atom as to position, relative mass and charge of protons, electrons, and neutrons.	Use the Rutherford model not the quantum mechanical model.	ALCHEM "Models of the Atom," A28 "Subatomic Particles," A31 Chemistry: A Modern Course "Rutherford-Bohr Atom," 8.10 Chemistry Experimental Foundations, 3rd ed. "Components of an Atom," 8.1 Chemistry: Experiments and Principles "Rutherford Models," 8.4 Chemistry Today "Structure of the Atom," 4.4

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
2.0 Differentiate between the atomic number and the atomic mass of an element.		ALCHEM "Arrangement of Sub-atomic Particles," A31 Chemistry: A Modern Course "Atomic Mass," 8.9 Chemistry Experimental Foundations, 3rd ed. "Atomic Number" and "Mass Number," 8.1 Chemistry: Experiments and Principles "Rutherford Model," 8.4 Chemistry Today, 2nd ed. "Structure of the Atom," 4.4
3.0 Define the isotope. 3.1 Identify the isotopes, given the atomic numbers and mass numbers for a group of atoms.	Have students identify from the symbol of an isotope, the number of neutrons, protons, and electrons of any neutral atom; e.g., $^{23}_{11}Na$.	ALCHEM "Single Ions" (done with ions), A34 Chemistry: A Modern Course "Isotopes and Atomic Numbers," 8.7 Chemistry Experimental Foundations, 3rd ed. "Mass Numbers and Isotopes," 8.1

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
4.0 Distinguish between atoms and molecules, elements and compounds.	Demonstration of two elements reacting to form a compound can be used to develop this concept; e.g., Smoot experiment, "Chemical and Physical Changes in Matter," could serve to demonstrate a variety of chemical reactions. Experiments and/or demonstrations should be attempted here to illustrate chemical changes such as combining solutions of Iron (III) chloride and silver nitrate, and the heating of a wood splint.	Chemistry: Experiments and Principles "Neutron and the Isotope," 8.6 Chemistry Today, 2nd ed. "Structure of the Atom," 4.4 ALCHEM "Classification of Substances," A4 Chemistry: A Modern Course "Chemical Formulas," 4.2 Chemistry Experimental Foundations "Elements and Compounds," 3.2 Chemistry: Experiments and Principles "Substances: Elements and Compounds," 2.5 Chemistry Today, 2nd ed. "Pure Substances," 3.6 "Development of Matter," 3.13 "Physical and Chemical Properties," 3.4

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry for Today: Laboratory Manual, 2nd ed. Experiment, "Observing Chemical Reactions" Experiment, "Observing More Chemical Reactions"
5.0 Relate the name of an element and its symbol.		ALCHEM "Atomic Symbols," A7 Chemistry: A Modern Course "Symbols," 4.1 Chemistry Experimental Foundations, 3rd ed. "Elements and Compounds," 3.2 Chemistry: Experiments and Principles "Elements and Compounds," 2.5 Chemistry Today "Symbols of Elements," 3.10
6.0 Know the names and symbols of the following common elements: H, Li, Na, K, Mg, Ca, Sr, Ba, Cr, Mn, Fe, Ni, Pt, Cu, Ag, Zn, Hg, Al, C,	This objective is long-term and will likely only be met at the end of the term. Work on learning and using the names and symbols should continue throughout the course.	ALCHEM "An Element Hunt," A8 Chemistry: A Modern Course "Symbols," 4.1

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
Si, Sn, Pb, N, P, O, S, F, Cl, Br, I, He, Ne, Ar, U.		Chemistry Experimental Foundations, 3rd ed. "Elements and Compounds," 3.2 Chemistry Today, 2nd ed. "Symbols of Elements," 3.10
7.0 Distinguish between a group (family) and a period with regard to its position on the periodic table.	Show the movie "Chemical Families" from Chem Study. Demonstrate properties of alkali metals with water.	ALCHEM "Chemical Families," A13-20 Chemistry: A Modern Course "Lanthanides and Actinides," 10.6 Chemistry Experimental Foundations, 3rd ed. "Regularities Among the Elements," 9.1 Chemistry: Experiments and Principles "Noble Gases," "Alkali Metals," "Halogens" 7.4-6 Chemistry Today, 2nd ed. "Mendeleev's Periodic Tables," 5.1

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		ALCHEM Experiment, "Properties and Applications of Elements" NOTE: Care should be exercised in the handling of mercury. Chemistry Today, 2nd ed. Experiment, "The Variation of Atomic Properties"
8.0 Locate the following groups on the periodic table: Alkalies, Alkaline Earths, Chalcogens (oxygen family), Halogens, Inert Gases.		ALCHEM "Classification Systems," A5-8 Chemistry: A Modern Course "Metals and Non-Metals," 10.9 Chemistry Experimental Foundations, 3rd ed. "Vertical Trends," 9.2-4 Chemistry: Experiments and Principles "Noble Gases," "Alkali Metals," "Halogens," 7.4-6 Chemistry Today, 2nd ed. "Features of Modern Periodic Tables," 5.2

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
9.0 Observe, organize, and classify elements in terms of appearance, metallic and non-metallic properties.	Use the movie "Chemical Families" to introduce this concept. Some laboratory activities where students handle and observe elements could be done here. The article entitled "Shell Games: Uncovering Periodic Properties" in The Science Teacher (May, 1983) is useful in suggesting mini-labs and demonstrations for developing the concept of periodic properties. Appropriate caution must be observed, particularly with the halogens.	ALCHEM "Classification Systems," A5-8 Chemistry: A Modern Course "Metals and Non-Metals," 10.9 Chemistry Experimental Foundations, 3rd ed. "Regularities Among the Elements," 9.1 Chemistry: Experiments and Principles "Introduction," 7.1 Chemistry Today, 2nd ed. "Metal, Metalloids, and Non-metals," 3.9 Chemistry Today Laboratory Manual, 2nd ed. Experiment, "Properties of Metals and Non-metals" Experiment, "Physical and Chemical Properties of Two Metals"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		ALCHEM Experiment, "Properties and Applications of Elements"
10.0 Relate metallic and non-metallic properties to the periodic table.	Some activities such as those relating properties of elements to their place in the Periodic Table should be done; e.g., "Building the Periodic Table" in ALCHEM and the experiment "The Periodic Law" from Neil Carmichael, Laboratory Chemistry (Columbus, OH: Chas. E. Merrill, 1983).	ALCHEM "Classification System," A4 Chemistry: A Modern Course "Metals and Non-Metals," 10.9 Chemistry Experimental Foundations, 3rd ed. "Horizontal Trends," 8.9 and 9.6 Chemistry Today, 2nd ed. "Features of Modern Periodic Tables," 5.2
11.0 Distinguish between an atom and an ion in terms of gain or loss of electrons.		ALCHEM "Simple Ions," A34-36 Chemistry: A Modern Course "Oxidation Number," 4.3 Chemistry Experimental Foundations, 3rd ed. "Gaining and Losing Electrons," 10.2

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
12.0 Predict the charge of a simple ion from its position on the periodic table.		Chemistry: Experiments and Principles "Electron-Proton Model," 6.6 Chemistry Today, 2nd ed. "Mendeleev's Periodic Table," 5.1 ALCHEM "Simple Ions," A34-36 Chemistry: A Modern Course "Oxidation Number," 4.3 "Predicting Oxidation Numbers," 10.13 Chemistry Experimental Foundations, 3rd ed. "The Noble Gases" and "Stable Groups of Electrons," 10.1 Chemistry Today, 2nd ed. "Ionic Bonding," 6.2
13.0 Write and name formulas of compounds formed between elements from the following groups: the Alkalies and Alkaline Earths with the Chalcogens (oxygen family) and the Halogens.	Refer to "Nomenclature of Inorganic Compounds" in the introductory section of this guide.	ALCHEM "Compounds, Bonding, and Nomenclature," B4-20 Chemistry: A Modern Course "Naming Compounds," 4.4

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
14.0 Write and name the formulas of simple binary compounds formed between non-metals and name ternary compounds using the IUPAC system.		ALCHEM "Prefix System of Nomenclature," B4-12 Chemistry: A Modern Course "Naming of Compounds," 4.4 Chemistry Experimental Foundations, 3rd ed. "Names of Compounds," 3.2
15.0 Relate the formation of ionic and covalent bonds to an atom's position on the periodic table.		ALCHEM "Class of Chemical Bonds," B2 Chemistry: A Modern Course "Bond Character," 12.6-9 Chemistry Experimental Foundations, 3rd ed. "Gaining and Losing Electrons," 10.2-3 Chemistry Experiments and Principles "Periodic Table," 7.1

CHEMISTRY 200 TIME: 15-16 hours

UNIT B: Concepts of Matter

RATIONALE: Stoichiometry is important to the quantitative understanding of chemistry and to further study in the sciences.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Define and apply the concept of a mole.	Have students do problems such as the following: i) Determine the number of grams in one mole of zinc. ii) Determine the number of grams in one mole of sulphuric acid. iii) Determine the number of litres in one mole of carbon dioxide gas at standard conditions. iv) Determine the number of atoms or molecules in one mole of a substance.	ALCHEM "Mole Relationships," Unit D Chemistry: A Modern Course "The Mole," 5.3 Chemistry: Experimental Foundations, 3rd ed. "Molecular Weight, The Mole, and Molar Volume," 2.2 Chemistry: Experiment and Principles "The Mole," 2.7 "Molar Mass," 2.8 "Molar Volume," 2.9 Chemistry Today, 2nd ed. "The Mole Concept," 3.15
2.0 Solve conversion problems involving grams, atoms, molecules, litres, and moles.	Have student solve such problems as the following: i) Determine the number of grams in 1.6 moles of NaCl.	ALCHEM "Moles to Mass Calculations," Unit D

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	ii) Determine the number of molecules in 50.0 g of $CuSO_4$. iii) Determine the number of atoms in 30.0 L of helium at S.T.P.	Chemistry: A Modern Course "The Mole," 5.3 Chemistry Experimental Foundations, 3rd ed. "Molecular Weight, The Mole, and Molar Volume," 2.2 "Elements and Compounds," 3.2 Chemistry: Experiments and Principles "Calculations Based on the Mole," 2.11 Chemistry Today, 2nd ed. "The Mole Concept," 3.15
3.0 Define and apply the concept of conservation of mass.	Develop the concept that 6.0 g of reactants produce 6.0 g of products. A demonstration and/or an experiment should be performed here to illustrate this law. An alternative to the silver nitrate reaction is the experiment, "Investigating the Law of Conservation of Mass-Energy" using lead chromate. This experiment is found in Carmichael, Laboratory Chemistry.	Chemistry: A Modern Course "Law of Conservation of Mass," 8.2 Chemistry Experimental Foundations, 3rd ed. "Conservation of Mass," 4.1 Chemistry: Experiments and Principles "Conservation of Mass," 3.3 Chemistry Today, 2nd ed. "The Laws of Chemical Change," 3.11

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry Experimental Foundations, 3rd ed. Experiment, "Mass Relationship Accompanying Chemical Change" CAUTION: Potassium chromate and lead nitrate salts are acute health hazards. Care should be exercised to avoid inhaling. The experiment should be performed in a fume hood. Chemistry: Experiments and Principles Laboratory Manual Experiment, "Conservation of Mass During Chemical Change" Chemistry Today Laboratory Manual, 2nd ed. Experiment, ""Mass Relationships in a Chemical Reaction"
4.0 Balance equations and solve problems involving stoichiometric calculations.	Have students solve problems such as the following: i) Calculate the number of grams of carbon dioxide produced when 25.0 g of propane are burned.	ALCHEM "Balancing Chemical Equations," Unit C "Mole to Mole Stoichiometry," Unit E

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry: A Modern Course "Balancing Equations," 6.2 "Mass-Mass Relationships," 7.1
		Chemistry Experimental Foundations, 3rd ed. "Balanced Chemical Equations," 4.1
		Chemistry: Experiments and Principles "Writing Equations for Reactions," 3.5 "Calculations Based on Chemical Equations," 3.6
		Chemistry Today, 2nd ed. "Balancing Chemical Equations," 10.4 "Mass Calculations Involving Chemical Equations," 13.10
	An experiment showing mole relationships used in balancing equations may be done here.	ALCHEM Demonstration, "The Reaction of Copper with Aqueous Silver Nitrate" Experiment, "A Precipitation Reaction"

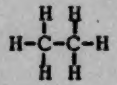
OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry Experimental Foundations, 3rd ed. Experiment, "The Behaviour of Solid Zinc in an Aqueous Solution of Lead Acetate" CAUTION: Lead Acetate is an acute health hazard. Wash hands thoroughly after using. Concentrated acetic acid requires care. Avoid inhalation of acetone vapours. Chemistry: Experiments and Principles Laboratory Manual Experiment, "Iron-Copper Chloride Reaction" Experiment, ""Copper-Silver Nitrate Reaction" Experiment, "Some Chemical Reactions of Copper and Its Compounds"
5.0 Identify a given equation as either endothermic or exothermic.	Have student determine whether $H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(g) + 284$ kJ is an exothermic or an endothermic reaction? Use joules or kilojoules as units.	Chemistry: A Modern Course "Energy and Chemical Change," 7.2 Chemistry Experimental Foundations, 3rd ed. "Energy Changes in Chemical Reactions," 4.2

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry: Experiments and Principles "Formation of Water," 3.1 "Decomposition of Water," 3.2 Chemistry Today, 2nd ed. "The Nature of Chemical Reactions," 10.1

CHEMISTRY 200 TIME: 10-12 hours

UNIT C: Organic Chemistry

RATIONALE: Organic chemistry is an increasingly important area of study which affects mankind through the production of many new materials with new properties. A basic understanding of the unique nature of carbon and the compounds it can form provides a base for further study in this area.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to: 1.0 Describe how carbon forms single, double, and triple bonds.	This should be treated simply: since carbon has four valence electrons, it forms four covalent bonds. Use dashes to represent bonds:  $\begin{array}{ccccccc} & & H & & H & & \\ & & \mid & & \mid & & \\ H & - & C & - & C & - & H \\ & & \mid & & \mid & & \\ & & H & & H & & \end{array}$ It is recommended that students build models of different, simple, hydrocarbons.	ALCHEM Unit H covers all objectives in this section. Chemistry: A Modern Course "Classes of Organic Compounds," Chapter 29 covers all objectives in this unit. Chemistry Experimental Foundations, 3rd ed. "Sharing Electrons: The Covalent Bond," 10.3 Chapter 19 covers all objectives in this unit to a minimal level, but the use of supplementary materials is recommended.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry: Experiment and Principles Chapter 16 covers all objectives in this unit except objective 5.0. Chemistry Today, 2nd ed. Chapter 16 covers all objectives in this unit.
2.0 Identify and distinguish among alkanes, alkenes and alkynes.	Use models to highlight the structural differences.	
3.0 Name non-branched aliphatic hydrocarbons to eight carbons.	Use of models would be helpful. Over-emphasis on drawing and naming should be avoided.	
4.0 Name and identify structural isomers of saturated aliphatic hydrocarbons.		
5.0 Discuss common use of aliphatic hydrocarbons by relating use to structure, bonding, and physical properties of the hydrocarbons.	Provide descriptive information about the uses of the hydrocarbons as fuels. Make comparisons of the burning rate and octane numbers of straight branched chains in gasoline. Detail the refined products of crude oil, relating the length of the chain to the molecular properties. Reference can be made to Andrews, et al. or "Fossil Fuels" in	Chemistry Today Laboratory Manual, 2nd ed. Experiment, "Preparation of t-Butyl Chloride" CAUTION: t-Butyl alcohol and especially t-Butyl chloride are acute hazards. Flames should be avoided.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	Science 100. Additional uses can be found in Alchem, Unit H or the module: Ethylene and its Derivatives. A demonstration on fractional distillation can be done.	ALCHEM Demonstration, "Fractional Distillation"
6.0 Differentiate between aliphatic and aromatic hydrocarbon structures.	The simple aromatic structure should be used to illustrate the differences. Discussions on resonance should be avoided. Use of models is recommended.	
7.0 Identify the functional groups for an alcohol, acid, and ester.	Emphasis should be placed on relating the compound to its common uses and to the student's environment; e.g., the difference between some alcohols; properties and uses of common acids; chemical composition of common flavourings. Opportunities should be provided to make simple compounds.	ALCHEM Experiment, "Esterification" Chemistry Experimental Foundations, 3rd ed. Experiment, "Preparation of an Ester" CAUTION: See general safety section.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
8.0 Be able to name an alcohol, acid or ester from a single structural formula, and list some properties and uses.		Chemistry Today Laboratory Manual, 2nd ed. Experiment, "Preparation of Ethanol by Fermentation" Experiment, "Esters" CAUTION: See general safety section. Chemistry Experiments and Principles Laboratory Manual Experiment, "The Preparation of Esters" CAUTION: See general safety section.
9.0 Write reactions for the combustion of an alcohol and the synthesis of an ester.		

UNIT D: Gases

RATIONALE: This unit provides background to problem solving within the nature of gases.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Differentiate among gases, liquids and solids using such physical properties as density, shape, volume, melting and boiling points.	A review of the simple differences of the three states is sufficient.	Chemistry: A Modern Course Chapter 15 covers all objectives 1.0 to 4.0. Chemistry: Experiments and Principles "Solid-Liquid Phase Changes," 5.2 "Liquid-Gas Phase Change," 5.3 Chemistry Today, 2nd ed. "The Three States of Matter," 3.2 "Changes in States of Matter," 3.3 "Physical and Chemical Properties," 3.4
2.0 Apply the kinetic molecular theory to explain changes in volume, number of molecules and temperature on the pressure exerted by a gas.	The model should be kept simple in the discussion of this objective; e.g., as the volume of a gas is decreased, the amount of space molecules occupy is also decreased,	

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	thereby increasing the number of collisions and hence the pressure. Have students apply the theory to pressure and heat relationships in a pump, lift and buoyancy in a balloon and other illustrations. Demonstrations of the concepts of pressure and temperature and their effects on volume should be attempted.	Chemistry Experimental Foundations, 3rd ed. Chapter 5 covers all objectives in this unit except objective 1.0. Chemistry: Experiments and Principles "Pressure-Temperature Regularity," 4.3 "Volume-Temperature Regularity," 4.4 "Meaning of Temperture," 4.5 Chemistry Today, 2nd ed. Chapter 14 covers all objectives in this unit.
3.0 Describe the operation of a Torricelli barometer.	A demonstration of this would be desirable. Kilopascals should be used as pressure units. However, the use and mention of millimetres of mercury cannot be avoided. Students should be acquainted with both systems.	Chemistry: Experiments and Principles "Measurement of Gas Pressure," 1.4
4.0 Change degrees Celsius to Kelvin and vice versa.		Chemistry: Experiments and Principles "The Meaning of Temperature," 4.5

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
5.0 Interpret the graph relationships of Boyle's and Charles' Law.	Have students construct graphs and interpret their shapes. Experiments and demonstrations should be done to illustrate these laws. For example, see Carmichael's Laboratory Chemistry experiment "Charles' Law: The Effect of Temperature on Volume" and demonstrations: "Relationship Between Pressure and Temperature: Kinetic Theory" or Boyle's Law: "The Effect of Pressure on Volume."	Chemistry: A Modern Course "Boyle's Law," 18.1 "Charles' Law," 18.4 Chemistry: Experiments and Principles "Pressure-Temperature Regularity," 4.3 "Volume-Temperature Regularity," 4.4 Chemistry Today Laboratory Manual, 2nd ed. Experiment, "The Effect of Pressure on the Volume of Gas" Experiment, "The Effect of Temperature on the Volume of a Gas"
6.0 Solve problems using Boyle's Law, Charles' Law, and $P_1V_1/T_1 = P_2V_2/T_2$.	Chemistry: Experiments and Principles is very weak on the on this objective; however, it can be supplemented from the laboratory activities suggested.	Chemistry: A Modern Course, "Applying Boyle's Law," 18.2 "Applying Charles' Law," 18.5 "Combined Gas Laws," 18.6 Chemistry: Experiments and Principles "Pressure-Temperature Regularity," 4.3 "Volume-Temperature

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Regularity," 4.4
7.0 Solve gas problems involving partial pressures in the collection of gases over water.	An experiment should be done here to give the student experience in collecting gases and to illustrate the importance of controlling variables such as temperature.	Chemistry: A Modern Course "Dalton's Law of Partial Pressure," 18.3 Chemistry: Experiments and Principles "Partial Pressure and Gases," 4.1
	The experiments on the reaction of a metal with hydrochloric acid can be used to illustrate the mole relationship in reactions.	Chemistry Today Laboratory Manual, 2nd ed. Experiment, "The Reaction of a Metal with Hydrochloric Acid" Chemistry: Experiments and Principles Laboratory Manual Experiment, "The Reaction of Magnesium with Hydrochloric Acid"

CHEMISTRY 200 TIME: 15-17 hours

UNIT E: Solutions

RATIONALE: This unit provides background to the further study of solutions, acids and bases, and equilibrium.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Describe how factors such as temperature and intermolecular forces affect the vapour pressure of a liquid.	A demonstration of the fact that liquids evaporate from open containers can be done; e.g., fumes from ammonia and hydrochloric acid placed into two watch glasses near each other will illustrate that evaporation has taken place. This can be used as a starting point to discuss the effect of forces and temperature on vapour pressure of a liquid.	Chemistry: A Modern Course "Measuring Vapour Pressure," 17.3 Chemistry Experimental Foundations, 3rd ed. "Liquid Vapor Equilibrium," 6.1 "Kinetic Theory for Vapour Pressure of a Liquid," 6.1 Chemistry: Experiments and Principles "Change of Vapour Pressure with Temperature," 5.5 Chemistry Today, 2nd ed. "Attractive Forces in the Liquid Phase," 9.2
2.0 Explain the relationship between the vapour pressure and the boiling point of a liquid.	Demonstrate boiling at reduced pressure.	Chemistry: A Modern Course "Boiling Point," 17.6

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry Experimental Foundations, 3rd ed. "Boiling Point," 6.1
		Chemistry: Experiments and Principles "Vapour Pressure in Liquid--Vapour Equilibrium," 5.4 "Change of Vapour Pressure with Temperature," 5.5
		Chemistry Today, 2nd ed. "A Liquid in an Open Container," 9.5
3.0 Identify the parts of a homogeneous solution; e.g., solute, solvent.		ALCHEM "Solutions," Unit I
		Chemistry: A Modern Course "Homogeneous Materials," 3.2
		Chemistry Experimental Foundations, 3rd ed. "Solutions," 6.2
		Chemistry: Experiments and Principles "Introduction," 6.0

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
4.0 Describe the differences between a pure liquid and a solution in terms of physical properties such as vapour pressure, boiling point and freezing point.	Have students interpret vapour pressure-temperature graphs. Demonstrate the effect on the vapour pressure of adding sugar or salt to water.	Chemistry Today, 2nd ed. "General Features of a Solution," 9.8 Chemistry Experimental Foundations, 3rd ed. "Solutions," 6.2 Chemistry: Experiments and Principles "Behaviour of Solutions During Phase Change," 6.1 Chemistry Today Laboratory Manual, 2nd ed. Experiment, "The Degree of Saturation of a Solution" Experiment, "Solutions and Molecular Polarity"
5.0 Prepare solutions of known molar concentrations.		ALCHEM "Concentrations of Solutions," Unit I Chemistry: A Modern Course "Molar Solutions," 18.9 Chemistry Experimental Foundations, 3rd ed. "Expressing the Composition of Solutions," 6.2

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry: Experiments and Principles "Expressing the Concentration of Solutions," 6.2 Chemistry Today, 2nd ed. "Concentration," 13.12 ALCHEM Experiment, "Preparation of a Standard Solution and Dilution of Known Solutions" Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Production of a Precipitate from Solutions of Sodium Iodide and Lead Nitrate" Chemistry: Experiments and Principles Laboratory Manual Experiment, "Formula of a Precipitate"
6.0 Solve problems involving preparation of solutions and dilution of same with water or like substances.	Have students: i) Calculate the mass of NaCl that is required to prepare 400 mL of a 0.50 mol/L solution. ii) Calculate the final concentration if 50 mL of water is added	ALCHEM "Solutions," Unit I Chemistry: A Modern Course "Molar Solutions," 21.9

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	to 25 mL 0.50 mol/L solution.	Chemistry Experimental Foundations, 3rd ed. "Expressing the Composition of Solutions," 6.2
	iii) Calculate the final concentration of the solution produced by adding 200 mL of 0.50 mol/L NaCl to 300 mL of 0.80 mol/L NaCl.	Chemistry: Experiments and Principles "Expressing the Concentration of Solutions," 6.2 Chemistry Today, 2nd ed. "Concentration," 13.12
7.0 Describe the effect of the dissolving of electrolytes on the conductivity of a solution.	Demonstrate the electrical conductivity of solutions.	ALCHEM "Dissociation," Unit I Chemistry: A Modern Course "Electrolytic Conduction," 27.2 Chemistry Experimental Foundations, 3rd ed. "Electrical Conductivity of Water Solutions," 7.4 Chemistry: Experiments and Principles "Variations Among Properties of Solutions," 6.4 Chemistry Today, 2nd ed. "Electrolytes and Non-Electrolytes," 9.13

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
8.0 Write ionic equations showing the dissolving of ionic solids in water.		ALCHEM "Dissociation," Unit I Chemistry: A Modern Course "Net Ionic Equations," 24.10 Chemistry Experimental Foundations, 3rd ed. "Electrical Conductivity of Water Solutions," 7.4 Chemistry: Experiments and Principles "Electrical Properties of Liquids and Solids," 6.7 Chemistry Today, 2nd ed. "Dissolving Ionic Substances," 9.14
9.0 Know the formula and names of the following ions: SO_4^{2-}, NO_3^-, CO_3^{2-}, PO_4^{3-}, OH^-, HCO_3^-, HSO_4^-, SO_3^{2-}, MnO_4^-, NH_4^+, CrO_4^{2-}, $Cr_2O_7^{2-}$	This is a long-term objective that will be met over the course of the program. Work on learning and using the names and formulas of the ions should continue throughout the program.	Solving Problems in Chemistry "Chemical Nomenclature," p. 29 Chemistry Experimental Foundations, 3rd ed. "Appendix 4"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
10.0 Know the ions with universal solubility in water: nitrates and acetates; ammonium, hydrogen, alkalies.		Chemistry: Experiments and Principles "Appendix 2" Chemistry Today, 2nd ed. Chart - pp. 181, 183 Chemistry: A Modern Course "Problem Supplement - Reactions and Ionic Equations," 20.2
10.1 Use a solubility chart to predict precipitate formations between ions.	It is not the intent that students memorize the chart at this time, but they should be made aware of its existence. This should not be overdone since it is repeated in Chemistry 300.	Chemistry Experimental Foundations, 3rd ed. "Solubility of Common Compounds in Water," 16.7 (Table) Chemistry: Experiments and Principles "Solubility of Ionic Compounds," 6.10 Chemistry Today Laboratory Manual, 2nd ed. Experiment, "Solutions and Solubility"
11.0 Write overall and net ionic equations showing the formation of precipitates from a mixing of ionic solutions.	This will be repeated in Chemistry 300; therefore, a brief presentation is recommended. Activities which use simple as well as complex ions	Chemistry: A Modern Course "Problem Supplement - Reactions and Ionic Equilibrium," 20.2

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	in precipitation reactions can be done.	Chemistry Experimental Foundations, 3rd ed. "Precipitation Reactions in Aqueous Solutions," 7.4 Chemistry: Experiments and Principles Laboratory Manual Experiment, "Reactions Between Ions in Aqueous Solutions" Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Reactions Between Ions" CAUTION: Barium nitrate, potassium, and sodium chromates are hazardous. Wash hands thoroughly while conducting this experiment. Chemistry Today Laboratory Manual, 2nd ed. Experiment, "Forming Precipitates and Balancing Equations"

chemistry 200 (options)

CHEMISTRY 200 TIME: 15 hours

UNIT: Chemistry of Photography

RATIONALE: This unit is designed to provide students with an understanding of some of the basic priniciples of the chemistry of light-sensitive substances and knowledge of simple laboratory procedures for photography. The skills which are developed by the student will be of later use either in the initial aspects of activities or a career.

PRIMARY REFERENCE:

1. Ashcroft, K. et al. Chemistry of Photography. SI ed. Toronto: Book Society of Canada, 1980.

NOTE: Most Kodak Data Books may be obtained at a camera shop locally or directly from Kodak, Department Six, 3500 Eglington Avenue West, Toronto, Ontario, M6M 1V3.

SUPPLEMENTARY REFERENCES:

1. Advanced Camera Techniques (AC-56). Rochester, NY: Eastman Kodak, 1977. (Good for camera technique)

#2. Basic Chemistry of Photographic Processing: Part 1 and 2. Rochester NY: Eastman Kodak, 1971. (Two programmed learning booklets that may serve as a source of test questions.)

3. Basic Developing, Printing, and Enlarging in Black and White (AJ-2). Rochester, NY: Eastman Kodak, 1977. (Good section on darkroom design.)

4. Brummitt, Wyatt. Photography is . . . Rev. ed. Garden City, NY: Amphoto (American Photographic Book Publishing Company, Inc.), 1977. (Also available from Kodak.)

#5. Darkroom Dataguide for Black and White. Toronto: Eastman Kodak. (Buy latest Version.)

#6. Eaton, George T. Photographic Chemistry. 3rd ed. New York: Morgan and Morgan, 1981.

7. Hattersley, R. Beginner's Guide to Photography. Toronto: Doubleday of Canada, 1974.

8. Index to Kodak Information. Rochester, NY: Eastman Kodak. (Published yearly; free catalogue of all data books, pamphlets, etc.)

9. Mees, C.E.K. The Theory of the Photographic Process. Toronto: Macmillan, 1971. (Very technical.)

10. Muse, Ken. Photo One: Basic Photo Text. Englewood Cliffs, NJ: Prentice-Hall, 1973. (Good for student self-teaching; full of easy to read cartoons.)

#11. Processing Chemical and Formulas for Black and White Photography. Rochester, NY: Eastman Kodak, 1977.

#12. Some Chemical Reactions in Photography. Rochester, NY: Eastman Kodak, 1977 (pamphlet AJ-15).

# These references are considered to be very useful for the teacher.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Describe the reactions that produce silver halides. 1.1 Observe and describe what happens when silver halides are exposed to light.	Have students prepare one or more silver halides and expose to light. CAUTION: Have students wash hands thoroughly after working with chemicals in this section.	Chemistry of Photography Experiment 1.1, "How Do Silver Compounds React to Light" and "Latent Image" Photographic Chemistry Chapter 4 Some Chemical Reactions in Photography
2.0 Describe the chemical reactions applicable to developing films and paper with regard to:		
- developer reactions;	Have students develop an exposed piece of photo paper in a commercial developer.	Chemistry of Photography Experiment 2.4, "Creating Pictures Without a Negative" Some Chemical Reactions in Photography
- stopping bath reactions;	Students can repeat the above activity (development) but add varying quantities of acetic acid to the paper developer. They should test pH in the various trials.	Photographic Chemistry Chapters 5, 7, 10, 11, "Processing Chemicals and Formulas for Black and White Photography"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
- fixing bath reactions.	Have students: Place fixed and un-fixed photograms outdoors in bright sunlight (about one hour). Place an undeveloped strip of 35 mm film directly into a fixing bath (may be done in daylight).	Similar concept to Chemistry of Photography, but easier to do. Experiment 2.3, "Using Sodium Thiosulfate"
3.0 Develop a roll of film (black or white - 35 mm or larger).		Kodak Darkroom Data Guide Films "Basic Developing, Printing, and Enlarging in Black and White" and "Processing Your Film" Chemistry of Photography Experiment 4.1, "Developing a Film" (Purchase D-76 commercially; do not mix it yourself; dilute 1:1 as manufacturer recommends.)
3.1 Make a contact print from that film.	Use a piece of 25 x 30 cm plate glass to hold down negatives and a 15 watt bult for 5 to 20 seconds about 1.5 metres from the photo paper.	Basic Developing, Printing, and Enlarging in Black and White "Proof Sheets and Making a Proof Sheet"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry of Photography Experiment, "Contact Printing"
4.0 Relate camera controls to proper exposure; sharp image.	Describe to students the controls such as f-stop, ASA setting and shuttered speed as they relate to the production of a sharp image (depth of field).	Chemistry of Photography "How the Camera Makes Images,"Chapter 3 - entire chapter
5.0 Describe the theory of producing a colour image.	Optional: Chemistry of Photography, experiment, "Developing Colour Transparencies," Part C. Instead of the Unichrome Kit, use commercial "Unicolor E6" process kit. (ALL OF THE ABOVE ACTIVITIES MAY BE ACCOMPLISHED WITH A FILM DEVELOPING TANK, A CAMERA, AND AN AREA YOU CAN DARKEN. AN ENLARGER IS NOT NECESSARY.) (IF YOU HAVE ACCESS TO AN ENLARGER, PROCEED TO 6.)	Chemistry of Photography "Latent Image," Chapter 4 Photographic Chemistry "Chemistry of Color Development," Chapter 8

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
6.0 Develop a black and white enlargement.	Have students produce a black and white enlargement.	Basic Developing, Printing, and Enlarging in Black and White "Enlarging" and "Making an Enlargement" Chemistry of Photography Experiment, "Making Enlargements from Negatives" (Use commercial paper, developers and fixer.)
7.0 Relate each ingredient within a developer and/or fixer to its chemical function.	Students should analyze the published formula of a typical: i) developer; ii) fixer. Limitations to laboratory activities 1. well-ventilated room; 2. darkroom (or coverable windows); 3. safety considerations relative to chemical allergies; many people are allergic to developer chemicals, such as hydroquinone, Metol (para-methylaminophenol sulfate) or Elon.	Basic Chemistry of Photography Processing, Part 2, pp. 8-16 OR Photographic Chemistry, "Solutions and Chemicals in Photographic Processing," Chapter 5 "Photographic Developers," Chapter 6 "Chemistry of Development," Chapter 7

CHEMISTRY 200 TIME: 10 hours

UNIT: Energy

RATIONALE: This unit is designed to illustrate how science and technology can be used to find replacements for a dwindling fuel supply. The student will review current sources of fuel for the transportation sector. A study of alternative fuels will be done so as to look at the possibilities for replacing traditional sources. Some of the current limitations of these alternatives will also be examined.

PRIMARY REFERENCE:

1. Stine, W.R. Applied Chemistry. 2nd ed. Toronto: Allyn and Bacon, 1981.

SUPPLEMENTARY REFERENCES:

1. Ashcroft, K. Chemistry of the Car. Agincourt, ON: Book Society of Canada 1981.
2. Energy Alternatives: A Report by the Special Committee on Alternative Energy and Oil Substitution. Ottawa: Canadian Government Publishing Centre, Supply and Services, Canada, 1981.
3. Fossil Fuels. Winnipeg: Manitoba Department of Education, 1982. (For Canadian Data)
4. Hill, J.W. Chemistry for Changing Times. Minneapolis: Burgess Publishing Company, 1980.
5. ISIS. Fossil Fuels. Toronto: Ginn, 1980.
6. Jenkins, Frank, ed. The Athabasca Tar Sands. Edmonton: J.M. LeBel, 1978.

7. Energy, Mines and Resources Canada. *Propoane Carburation: Some Technical Considerations*. Ottawa: Minister of Supply and Services, 1983.

8. Manitoba Department of Education. *Energy from Chemistry: A Chemistry 200 Option*. Winnipeg: The Department, 1983.

The above publication includes articles which discuss chemical alternatives. Examples are "Fuel Duel," "Liquid Fuels from Biomass," "Hydrogen Fuel" and "Alternate Vehicle Fuels Pose Challenge for the Future." The publication is available *on loan* from the Department of Education Library. When requesting the material, use the call number 540.712712 C44C.

The Energy Information Centre, Colony Square, 500 Portage Avenue, Winnipeg, Manitoba, is a good source of excellent reference materials for use in the classroom.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Differentiate among the common fossil fuels as to composition, source and use.	Review with students the fossil fuels--coals, oil, and natural gas--as to their chemical composition, sources and main use.	ISIS: Fossil Fuels Applied Chemistry "Energy: The Problems and Some Conventional Solutions," Chapter 9 Chemistry for Changing Times "Energy: The Chemical Century," Chapter 12
2.0 Differentiate between the common energy and power units.	Acquaint the students with the different energy and power units in use today; e.g., B.T.U., calories, joules, watts, and kilowatt-hours. Some problems involving calculation of units and converting from one unit to another should be attempted.	Applied Chemistry "Energy: The Problems and Some Conventional Solutions," Chapter 9
3.0 Differentiate between ordinary gasoline and gasohol as to composition, octane rating, and energy content.	A look at the composition of gasoline and how the octane rating is determined should be attempted. A comparison of the use of methanol and ethanol in gasoline to produce gasohol should be examined in terms	Applied Chemistry "Energy: Alternatives for the Future," Chapter 10 Chemistry of the Car "Chemistry of Oil," Chapter 2

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	of octane rating and fuel efficiency. Have students compare the combustion of gasoline, methanol and ethanol by writing chemical reactions and compare their molar heats of combustion.	Engineering Journal, June '81 "Alternate Vehicle Fuels Pose Challenge for Future"
4.0 Compare processes for the production of methane, methanol, and ethanol from biomass.	The process by which each of these chemicals is obtained from a biosource should be examined. The chemical equations describing the process for each of these should be studied. A project could be the construction of a small biogas digester to produce a flammable fuel.	Applied Chemistry "Energy: Alternatives for the Future," Chapter 10 Engineering Journal, June '81 "Alternate Vehicle Fuels Pose Challenge for Future" "Liquid Fuels from Biomass"
5.0 Describe how hydrogen could be produced and used as a fuel.	An explanation of industrial preparations for hydrogen and some of the technological limitations of its use should be examined such as the ease in preparing these but the difficulty in storing them.	Applied Chemistry "Energy: Alternatives for the Future," Chapter 10 Hydrogen Fuel

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
6.0 Compare the advantages and disadvantages of using gasohol, methane, methanol, ethanol, natural gas, propane, hydrogen as a transportation fuel.	Factors to be studied should include: i) availability; ii) ease of production; iii) safety of use; iv) efficiency as a fuel.	Canadian Consumer, June '81 "Fuel Duel" Alcohols: A Technical Assessment of their Application as Fuels CNG: The Natural Alternative to Gasoline
7.0 Describe the operation of a fuel cell.	The design, function and chemistry of a fuel cell should be explored.	Applied Chemistry "Energy: Alternatives for the Future," Chapter 10
8.0 Compare the advantages and disadvantages of using electricity as an alternative to a liquid fuel in the transportation sector.	Discuss the production of electricity using conventional cells and other kinds of cells, and some of the technological limitations of these sources.	Applied Chemistry "Energy: Alternatives for the Future," Chapter 10
9.0 Compare the production and use of alternative fuels quantitatively.	A comparison should be made on an energy-in vs. energy-out basis: is it a gain or a loss?	Alcohols: A Technical Assessment of their Application as Fuels Applied Chemistry "Energy: Alternatives for the Future," Chapter 10

CHEMISTRY 200 TIME: 10 hours

UNIT: Polymers

RATIONALE: The discovery and manufacture of polymers has been made possible because of the interdependency of science and technology. Because of dwindling natural resources, students should examine the interdependence of human material comfort and their environmental effects, learn to recognize and examine the trade-offs (technological and economic) which are available to solve problems.

PRIMARY REFERENCES:

To do this unit, one of the following should be used.

1. Hill, J.W. et al. Chemistry for Changing Times. 3rd ed. Minneapolis: Burgess, 1980.

OR 2. Stine, William. Applied Chemistry. 2nd ed. Toronto: Allyn and Bacon Canada, 1981.

OR 3. Jenkins, F. ALCHEM: Ethylene and Its Derivatives. Edmonton: J.M. LeBel, 1979.

OR 4. Jarvis, B. et al. Form and Function. New York: Harper and Row, 1978.#

SUPPLEMENTARY REFERENCES:

1. Jenkins, F. ALCHEM: Food and Its Analogs. Edmonton: J.M. LeBel Enterprises, 1979.

2. Reid, N. The Amsyn Problem. Glasgow: The Scottish Council for Educational Technology, 1979. (For objective five in this unit.)

3. Johnstone, A.H. et al. The Vinyl Chloride Problem. Glasgow: Scottish Council for Educational Technology, 1982. This examines alternative ways to produce vinyl chloride.

# Supplement with Teacher References in either Chemistry for Changing Times or Applied Chemistry.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 State that polymers (plastics) are made up of monomers and describe examples.	Given the structural formula of any polymer, the student should be able to identify the monomer units but not necessarily the name of the polymer. The student should be able to write the structure of some polymers (e.g., polyethylene, PVC), given the name.	Applied Chemistry, 2nd ed. "Polymers," 6.5 Chemistry for Changing Times "Polymers," 6.5 ALCHEM: Ethylene and its Derivatives "Polyethylene" and "Polyvinyl Chloride" Form and Function "From Monomer to Polymer" "Natural and Synthetic Polymers"
2.0 Describe how polymers are made: addition polymers and condensation polymers; e.g., polyethylene, polyesters, and nylon.	The student should recognize that the loss of the multiple bond occurs with the formation of an addition polymer. Given two monomers, the student should be able to construct a dimer or a trimer by elimination of H_2O or HCl molecules. The experiment, "Preparation of Soap, Synthetic Rubber and Nylon" can be done by using Carmichael's Laboratory Chemistry as a reference. CAUTION: Ethylene dichloride (1, 2-Dichloroethane) is a strong	Chemistry for Changing Times "Polymers: Giants Among Molecules," Chapter 14 Applied Chemistry, 2nd ed. "Polymers," 6.5 "Condensation Polymers," 6.6 ALCHEM: Ethylene and its Derivatives "Polyethylene"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	irritant that can be absorbed through the skin. It can be hazardous. Hexane -1, 6- diamine irritates the eyes and skin. Avoid contact. Decanedioyl chloride or sebacyl chloride may be absorbed through the skin. Handle carefully.	
3.0 Describe the manufactured processes and uses of polymers: especially those of polyethylene, PVC, nylon, and polyesters.	The student should know the use of at least all of the polymers mentioned here. A number of samples of materials made from polymers could be brought into class, and identified as to which polymer each sample contains.	Chemistry for Changing Times "Polymers: Giants Among Molecules," Chapter 14 Applied Chemistry, 2nd ed. "Polymers," 6.5-8 ALCHEM: Ethylene and its Derivatives "Polyethylene" and "Polyvinyl Chloride" Food and its Analogs Form and Function "Properties of Polymers," "Natural and Synthetic Polymers,"
4.0 Compare the advantages and disadvantages of producing polymers.	A class discussion on the advantages and disadvantages of using polymers should be encouraged. These include tailor making of products with cer-	Chemistry for Changing Times Chapter 14

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	tain properties; limitations in the supply of raw materials; production of pollutants.	Applied Chemistry 2nd ed. ALCHEM Ethylene and its Derivatives Form and Function "Properties of Polmers" "Natural and Synthetic Polymers"
EXTENSION		
5.0 Identify the significant elements of an issue as well as their logical relationships, the implications of the issue, and the trade-offs, both technological and economic, which must be made to resolve it. 5.1 Evaluate alternative solutions.	The class may be divided into role-playing groups such as the management team, labour, government and citizens, and then given the task of studying the alternatives from their particular perspective and coming to a consensus on a solution to the Amsyn Problem. If the teacher desires, the particular issue mentioned above may be replaced by any similar problem on polymer production for which background information can be obtained.	Amsyn Problem This objective is not developed in any of the other references given in this section.

CHEMISTRY 200 TIME: 10 hours

UNIT: THE CHEMISTRY OF FOOD ADDITIVES

RATIONALE: This unit is designed to illustrate the role of science and technology in creating human comfort. The student will learn to recognize the differences among food additives and the reasons for placing them into food. The student could then use this information to make consumer decisions and to interpret government legalization procedures. The latter experience may lead to discussion of trade-offs in decision making

To fulfill the objectives of this unit, Food Additives in Action, alone, can be used or one of the texts and one of the lab manuals.

PRIMARY REFERENCES:

TEXTS:

1. Department of Health and Welfare. Food Additives in Action. Ottawa: Minister of Supply and Services Canada, 1982.

OR

2. Hill, J.W., et al. Chemistry for Changing Times. Minneapolis: Burgess, 1980.

OR

3. Stine, W.R. Applied Chemistry. 2nd ed. Toronto: Allyn and Bacon, 1981.

LABORATORY MANUALS:

1. Eby, D., and Tatum, R. The Chemistry of Food. Seattle: Unigraph, 1977.

OR

2. Eby, D., and Tatum, R. The Chemistry of Food Additives. Seattle: Unigraph, 1978.

OR

3. Summerlin, Lee. Chemistry of Common Substances. Morristown, NJ: Silver Burdett, 1979.

ENTARY REFERENCES:

1. ALCHEM: Food and their Analogs. Edmonton: J.M. LeBel, 1979.
2. Clydesdale, Fergus, ed. Food Science and Nutrition: Current Issues and Answers. Englewood Cliffs, NJ: Prentice Hall, 1979.
3. Lewis, John. Science in Society: Food. London: Heinemann, 1981.
4. Whelan, E.M., and Stare, F.J. Panic in the Pantry: Food Facts, Fads and Fallacies Battleboro, VT: The Book Press, 1977.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Identify by name and general structure, some examples of the following food groups: carbohydrates, proteins, vitamins, and minerals.	Have students test common foods for the presence of these classifications of molecules. Lists of such examples are included in Food Additives in Action, Worksheet number six and Chemistry for Changing Times, Chapter 17. Have students list their diet for a day and use nutrition charts to determine how much of each group they consume daily. CAUTION: Clorinated hydrocarbons are hazardous. Care should be used with concentrated sulfuric and nitric acids. Molisch reagent contains α napthol which can be hazardous.	Chemistry for Changing Times "Food: Those Incredible Chemicals," Chapter 16 Applied Chemistry "Carbohydrates," Chapter 8; "Fats and Oils," Chapter 18 Chemistry of Food Experiment, "Some Nutrients in Milk" Chemistry of Common Substances Experiment, "Testing for Carbohydrates" Experiment, "Tests for Protein" Experiment, "Testing for Starch" Experiment, "Potassium in Coffee and Tobacco"
2.0 Identify factors which influence consumer selection of food products.		Food Additives in Action "Consumers Choice," Unit 5

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
3.0 Define the term, food additives.	The following is the definition given in Food Additives in Action as the legal definition in Canada: "A food additive is any substance, including any source of radiation, the use of which results or may be expected to result in it or its by-products becoming a part of or affecting the characteristics of food." There are some interest groups that would include sugar, artificial flavourings and incidental additives obtained in processing. You may wish to discuss this with your class. (These other items are covered separately by the Food and Drug Regulations.)	Food Additives in Action "What is a Food Additive?" Unit 1 Chemistry for Changing Times "Food Additives: Bane or Blessing?" Chapter 17 Applied Chemistry Food Preservation," Chapter 17
4.0 Use reference material to identify additives and their uses.	Have students use food labels and determine which chemicals listed are food additives and why they would be used in that food. You might wish to select several frequently used additives for students to study to learn their function.	Food Additives in Action "Identifying Food Additives," Unit 2 Chemistry for Changing Times "Food Additives: Bane or Blessing?" Chapter 17 Applied Chemistry "Food Preservation," Chapter 17

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
5.0 Determine, through experimentation and research the function of selected food additives.	Some experiments can be done to identify some additives. CAUTION: Petroleum ether is extremely flammable and can be hazardous to health.	Food Additives in Action Experiment, "Preservation" Experiment, "Emulsifying Agents" Experiment, "Bleaching Agents" Experiment, "Anti-Foaming Agents" Chemistry of Common Substances Experiment, "Making Cheese" Experiment, "The Chemistry of Bruised Fruit" Experiment, "Pectin in Fruit Juices"
6.0 Describe and/or apply techniques used in food technology.	Have students identify additives in foods.	Food Additives in Action Experiment, "Natural and Synthetic Colours" Experiment, "Sequestering Agents"
6.1 Test foods for the presence of specific additives.	Have students do experiments to identify additives in foods. CAUTION: Use adequate sulfuric acid and $BaCl_2$.	Chemistry of Food Additives Experiment, "Detecting Calcium Propionate in Bread" Experiment, "Analysis of Fruit Juice for

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Vitamin C" Chemistry of Common Substances Experiment, "Sulfur Dioxide in Foods" Experiment, "Calcium Propionate in Bread" CAUTION: Barium chloride can hazardous.
6.2 Identify methods for determining additive safety.	Look at case studies of additive implementation.	Food Additives in Action "Control of Additives," Unit 4
7.0 Identify the advantages and disadvantages that might arise from the use of food additives in foods.	Use of resource people, speakers, etc., would help to create interest in this topic.	Chemistry for Changing Times "Food Additives: Bane or Blessing?" Chapter 17 Applied Chemistry. "Food Preservatives," Chapter 17
8.0 Use the materials in this unit to evaluate the use of additives in food products.	A simulation similar to that used in Food Additives in Action might be used. In this activity, a class is divided into groups representing a company, the Health Protection Branch and consumer groups. The group representing a company submits a proposal on a new additive to the Health Protection Branch, which will	Food Additives in Action. "Control of Additives," Unit 4 "Consumers' Choice," Unit 5

BJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	evaluate the proposal, and to the consumer groups, which will lobby the Health Protection Branch. Debates or critical essays could be assigned on such topics as: i) Are additives necessary for successful marketing of some food products? ii) What is the relationship between hyper-activity and use of food additives? The class could do some comparison shopping and then some analysis of similar products to evaluate the importance of an additive that is present in one but not others. Consumer Reports and Canadian Consumer are excellent sources of topics for discussion on foods and food additives.	

CHEMISTRY 200 TIME: 10 hours

UNIT: CHEMICALS AS DRUGS

RATIONALE: This unit is designed to illustrate the importance of science and technology in creating human comfort. Through this unit, the student will be introduced to biochemistry and the link between the physiological effects of drugs and the chemical reaction which produces the effect. If the teacher wishes and the materials are available, this unit could be extended to provided an exercise for the student in using scientific information to make decisions.

To fulfill the objectives of this unit, a teacher can select one of the three texts and one of the three laboratory manuals.

PRIMARY REFERENCES:

TEXTS:

1. Birenbaum, Lou. Chemistry of Man and Molecules. Agincourt, ON: Book Society of Canada, 1980.

OR

2. Hill, J.W. Chemistry for Changing Times. Minneapolis: Burgess Publishing Company, 1980.

OR

3. Stine, W.R. Applied Chemistry. 2nd ed. Toronto: Allyn and Bacon, 1981.

LABORATORY MANUALS:

1. Eby, D., and Tatum, R. The Chemistry of Over-the-Counter Drugs. Seattle: Unigraph, 1977.

OR

2. Kowalski, S.W. Consumer Science. Minneapolis: Burgess, 1981.

OR

3. Summerlin, Lee. Chemistry of Common Substances. Morristown, NJ: Silver Burdett, 1978.

SUPPLEMENTARY REFERENCES:

1. Johnston, A.H. ed. To Market a Drug. Glasgow: Scottish Council for Educational Technology, 1982. This material uses data dealing with side effects to examine safety in marketing of a drug.

2. Liska, Ken. Drugs and the Human Body. New York: Macmillan, 1981.

3. Long, J.W. The Essential Guide to Prescription Drugs: What You Need to Know for Safe Drug Use. 3rd ed. New York: Harper and Row, 1982.

4. Narcotics, Sedatives, Stimulants, and Psychedelics (Sound cassette, filmstrip series). Pleasantville, NY: Guidance Associates, 1978.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
student should be able to: Differentiate among the major drug classifications and become familiar with names and terms related to the classifications.	Three suggested classifications are: i) over-the-counter drugs; ii) prescription drugs; iii) illicit drugs. The student should learn a working definition of each class of drugs and be familiar with some common examples of each. Several definitions are available, but the following are representative: i) non-prescription drugs (over-the-counter): any drug legally purchasable without prescription; ii) prescription drugs: any drug legally purchasable with a doctor's prescription; iii) illicit drugs: drugs acquired for illegal, non-medical use; these include illegal narcotics such as heroin, as well as prescription drugs such as amphetamines.	

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
2.0 Identify the normal biochemistry of a drug target area in the body and indicate the changes produced by the drug.	Limit the study by choosing either one drug from each classification or one classification. The class could look at the normal synaptic transmission and changes produced by a drug. Have a pharmacist or biochemist in the medical field (not a doctor) speak to students on prescription drugs and their effects.	Chemistry of Man and Molecules "The Human Body," Chapter 1 Chemistry for Changing Times "Body Chemistry", Chapter 22 "Chemistry of the Mind," Chapter 23 Applied Chemistry Immunochemistry," Chapter 20 "Chemotherapy for the Treatment of Disease," Chapter 21 "Chemotherapy for the Treatment of Symptoms of Drug Abuse," Chapter 22 "Steroids and Birth Control," Chapter 23 Consumer Science "Effects of Cigarettes on Living Animals Lab"
3.0 Describe the effects of interactions of drugs (including synergistic effects).	Some examples of interactions can be explored such as: i) barbituates and alcohol; ii) aspirin and alcohol; iii) tetracycline and milk;	Chemistry of Man and Molecules "Medicines in Combination," Chapter 11

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	iv) aspirin and acetominophen; v) warfarin (an anticoagulant) with sulfanomides. This is a synergistic effect.	Chemistry for Changing Times "Chemistry of the Mind," Chapter 23 Applied Chemistry "Chemotheraphy for the Treatment of Symptoms of Drug Abuse," Chapter 22
4.0 Prepare and/or compare different types of over-the-counter drugs.	Students can do preparation experiments for over-the-counter drugs.	Chemistry of Man and Molecules Experiment, "Making Aspirin" CAUTION: Acetic anhydride is very corrosive to the skin. Chemistry of Common Substances Experiment, "Making Aspirin"
	Students can do some comparison of various over-the-counter drugs. These can be consumer (value for money) comparisons or analysis for various ingredients.	Chemistry of Man and Molecules Experiment, "Destructive Distillation of a Cigarette" Experiment, "Acid Neutralizating Properties of Antacids" Experiment, "What is in Headache Tablets"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry of Common Substances Experiment, "Testing Antacid Tablets" Chemistry of Over-the-Counter Drugs Experiment, "An Aspirin Lab" Experiment, "Neutralizing Excess Stomach Acid" Consumer Science Experiment, "Headache Preparations Lab"
5.0 Examine the influence of drugs on an individual's lifestyle.	Have students visit the local drugstore to obtain a list of the: - ten most commonly sold non-prescription drugs sold in their neighborhood; - ten most commonly sold prescription drugs. Have a member of the police drug squad talk on illicit drugs. Visit a detoxification centre. Invite a doctor, pharmacist or a social worker to talk about the positive effects of drugs or the problem of drug abuse.	Chemistry of Man and Molecules "Where Are We Going?" Chapter 12 Applied Chemistry "Chemotherapy for the Treatment of Symptoms of Drug Abuse," Chapter 22

chemistry 300 (core)

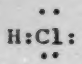
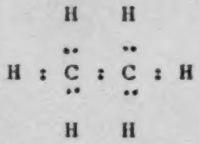
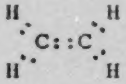
CHEMISTRY 300 **TIME: 17-19 hours**

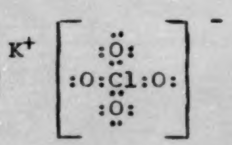
UNIT A: **Electronic Structure, Bonding, Periodic Table**

RATIONALE: An understanding of electronic structure, bonding and their relationship to the periodic table is important to the prediction of the behaviour of substances in chemical reactions.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Calculate the wave length or frequency using $\lambda = c/\nu$ or $\nu = c/\lambda$.		Chemistry: A Modern Course "Spectroscope," 8.11 "Planck's Hypothesis," 8.13 "Visible and Ultraviolet Spectroscopy," 8.12
2.0 Identify the parts of the electromagnetic spectrum in terms of their comparative wave lengths, frequencies, and energies.	Demonstrate the use of a spectroscope to observe continuous and line spectra of various elements.	Chemistry: Experimental Foundations, 3rd ed. Objectives 1.0 to 8.0 are covered in Chapter 11.
3.0 Calculate the energy of light using $E = h\nu$.		Chemistry: Experiments and Principles Objectives 1.0 to 8.0 are covered in Chapter 9.
4.0 Relate electron transition between energy levels to line spectra produced by a flame or gas discharge tube.	A demonstration could be done here on flame tests; e.g., the experiment "Flame Tests," in Carmichael's Laboratory Chemistry.	

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
5.0 Explain the quantum model of the atom in terms of: • energy levels; • principal quantum number; • orbitals as a region of probability s, p, d, f.	A simple definition of the region of probability of s, p, d, f, electrons should be used. The shelf model is recommended to introduce the concept.	Chemistry: A Modern Course "Principal Quantum Number," 9.8 to "Electron Dot," 9.14 covers objectives 5.0, 6.0 and 8.0.
6.0 Write out electron configuration to atomic number 18, Argon, and relate to the periodic table.	Electron configuration beyond 18 may be attempted if desired.	
7.0 Explain how ionization energy is related to electron configuration and the periodic table.		Chemistry: A Modern Course "Determining Ionization Energy," 12.1 to "Multiple Ionization Energies," 12.3
8.0 Use ionization energy or electronic configuration to predict the valence of an atom.	For example, given a series of ionization energies, have students predict the number of valence electrons. E_1= 46 kJ/mol, E_2= 90 kJ/mol, E_3= 1500 kJ/mol.	
9.0 Define and explain the formation of ionic, covalent, and multiple bonds.	Simple ionic: $Na^+ \left[:\underset{\cdot\cdot}{\overset{\cdot\cdot}{Cl}}: \right]^-$	Chemistry: A Modern Course "Electronegativity," 12.5 to "Polyatomic Ions," 12.11 covers objectives 9.0, 10.0, 11.0, 12.0.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	Covalent:  $H:\overset{..}{\underset{..}{Cl}}:$ Multiple: C_2H_6 ethane  $H:\overset{H}{\underset{H}{\overset{..}{\underset{..}{C}}}}:\overset{H}{\underset{H}{\overset{..}{\underset{..}{C}}}}:H$ C_2H_4 ethene (ethylene)  C_2H_2 ethyne (acetylene) $H:C:::C:H$	Chemistry Experimental Foundations, 3rd ed. Chapter 10 covers objectives 9.0 and 10.0. Chemistry: Experiments and Principles Chapter 10 covers objectives 9.0 and 10.0.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
10.0 Draw electron dot diagrams of ionic, covalent, and co-ordinate covalent (dative) bonded molecules and ions.	Basic simple molecules indicating the existence of these types of bonds can be presented, e.g.,  $K^+\left[\begin{array}{c} :\ddot{O}: \\ :O:\ddot{\underset{..}{Cl}}:O: \\ :\underset{..}{\ddot{O}}: \end{array}\right]^-$ coordinate covalent (dative) H:C:::N: covalent	Chemistry Experimental Foundations and Chemistry: Experiments and Priniciples These books do not have an electronegativity table.
11.0 Relate the organization of the periodic table to ionization energy, reactivity, atomic radius, and electronegativity.	Have students note trends from left to right on periods and top to bottom in families or groups. Have students predict the differences in these properties between two elements in a period or family and explain them.	Chemistry Experimental Foundations, 3rd ed. "Ionization Energy," 10.4 Chemistry: Experiments and Principles "Ionization Energy," 7.3

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
12.0 Use electronegativity values to predict the type of bond (ionic or covalent) formed between two elements, and the polarity of two atom molecules.	To illustrate the application of polarity, the concept of "like dissolves like" can be used, e.g., sodium chloride (polar) dissolves in water (polar), sodium chloride (polar) does not dissolve in gasoline (non-polar).	Chemistry: A Modern Course "Polarity," 14.1 "Weak Forces," 14.2 Chemistry Experimental Foundations, 3rd ed. "Bond Types," 12.3 Chemistry: Experiments and Principles "Polar Molecules in the Gas Phase," 17.1

CHEMISTRY 300 TIME: 12 hours

UNIT B: Reaction Rate and Chemical Equilibrium

RATIONALE: This unit provides an introduction to the factors that affect the rate of a reaction and the principles of chemical equilibrium that will be applied to further study in acids, bases, and solubility.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Define rate in terms of some quantity per unit of time.		Chemistry: A Modern Course All objectives in this unit are contained in Chapter 23 unless otherwise specified. Chemistry Experimental Foundations, 3rd ed. All objectives in this unit are contained in Chapter 15 unless otherwise specified. Chemistry: Experiments and Principles All objectives in this unit are contained in Chapter 12 unless otherwise specified.
2.0 Explain, using molecular concepts, how the nature of reactants, changes in concentration, temperature, and the addition of a catalyst affect the rate of reaction.	Demonstrations and/or experiments should be used to illustrate this objective.	Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "The Clock Reaction"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry: Experiments a Principles Laboratory Manual Experiment, "A Study of Reaction Rates"
0 Explain why a reaction takes place in a series of steps and the slowest step is the rate determining step.	Demonstration of "Old Nassau" can illustrate this objective. Old Nassau Reaction Prepare three separate 1.0 L solutions as follows: i) Solution A: 15.0 g of KIO /L ii) Solution B: Dissolve 4 g of starch in 500 mL of water and add to 500 mL of water containing 15 g of $NaHSO_3$ (a freshly prepared solution of $NaHSO_3$ should be used). iii) Solution C: 3.0 g of $HgCl_2$/L. Mix equal portions of the solutions (e.g., 25 mL) in the following order: B+C+A. This mixture will first be colourless, then orange, then black. To slow down the reaction, add an equal amount of water (25 mL) at the beginning.	

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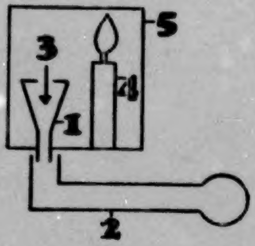
OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
Describe, using molecular concepts, how changes in surface area affect the rate of heterogeneous reaction.	A demonstration of a dust explosion should be attempted to illustrate this, such as using lycopodium powder.  1 - funnel 2 - rubber hose and bulb 3 - lycopodium powder on glass wool 4 - candle 5 - 4 L paint can Powdered zinc and lump of zinc in hydrochloric acid (demonstration). CAUTION: Powdered zinc reacts very rapidly. Use small amounts.	Initially test the activi before attempting it with students. Use appropriat cautions and shields.
Apply collision theory and the role of activation energy in determining rate of reaction.	Have students apply this to single step reactions, e.g., $A(g) + B(g) \longrightarrow C(g)$.	

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
6.0 Draw and interpret potential energy diagrams for endothermic and exothermic reactions.	Use models or examples such as: i) pole vaulter attempting to get over a bar; ii) car over mountain. Given reaction coordinate diagrams, students should identify reactants, products, activated complexes, and enthalpy changes (ΔH).	
7.0 Explain chemical equilibrium in terms of equal rates of forward and reverse reaction.		Chemistry Experimental Foundations, 3rd ed. "Recognizing Equilibrium," 13.1 Chemistry Experiments and Principles "Equilibrium Chemical Systems," 16.2
8.0 Apply Le Chatelier's Principle to predict how an equilibrium system will respond to changes in concentration.	Do not attempt to teach for mastery at this time, just introduce the principle. Le Chatelier's Principle is reintroduced in acid-base and solubility equilibria. Demonstrate this principle by using the $Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftarrows FeSCN^{2+}_{(aq)}$ equilibrium.	Chemistry Experimental Foundations, 3rd ed. "Predicting New Equilibrium Concentrations: Le Chatelier's Principle," 16.4 Chemistry Experiments and Principles "Le Chatelier's Principle: A Regularity," 13.7

BJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Demonstration Experiment, "Chemical Equilibrium: Qualitative Aspects"

TIME: 22-24 hours

UNIT C: Ionic Equilibria - Acids and Bases

RATIONALE: Acids and bases are important substances in many chemical reactions, both inorganic and organic. A study of them can also be used to examine equilibrium changes.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Differentiate between electrolytes and non-electrolytes and between strong and weak electrolytes.	A demonstration with a conductivity apparatus can be done to show the difference between a strong and a weak base.	Chemistry: A Modern Course All objectives in this unit are contained in Chapter 24 unless otherwise specified. Chemistry: Experiments and Principles All objectives in this unit are contained in Chapter 17 unless otherwise specified. Chemistry Experimental Foundations, 3rd ed. All objectives in this unit are contained in Chapter 14 unless otherwise specified.
2.0 Identify an acid, base and a salt from their respective formulae and properties.	Illustrate the properties using indicators, taste tests, conductivity apparatus, and some simple reactions.	

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
Differentiate between strong and weak acids and strong and weak bases. Identify them in common substances found in the school or home.	Test substances found in the school and ones students have brought from home.	
Know the names and formulas of common acids and bases such as: HCl, CH_3COOH, HNO_3, H_2SO_4, $NaOH$, KOH, NH_4OH.		
Define the process of neutralization.	Neutralization should be defined as a simple hydrogen ion, hydroxide ion cancelling. The principle of neutralization can be illustrated with a titration experiment.	
Solve problems involving acid-base neutralization.	For example, have students determine how many mL of 0.50 mol/L $Ba(OH)_2$ solution is required to neutralize 35 mL of 0.60 mol/L HCl solution.	Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Quantitative Titration" Chemistry Experiments and Principles Laboratory Manual Experiment, "Acid-Base Titration"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
7.0 Define pH and relate the relative acidity to the pH of common substances.	Have students use a pH meter to test the pH of common substances.	Chemistry: A Modern Course "pH Scale," 25.3
8.0 Solve problems using pH.	Problems should be attempted such as "If the H+ concentration of an acid is 3.4 x 10^{-5} mol/L, find the pH.	Chemistry: A Modern Course "pH Scale," 25.3
9.0 Identify acids and bases using the Bronsted-Lowry definition.		
10.0 Describe the nature of acid-base reactions as an equilibrium.		
10.1 Use Le Chatelier's Principle to predict the effect of changes in concentration or the addition of a common ion on an acid-base equilibrium.	Demonstrations should be done to illustrate the shifting of an equilibrium; e.g., $2H^+_{(aq)} + 2CrO_4^{2-}{}_{(aq)} \rightleftharpoons Cr_2O_7^{2-}{}_{(aq)} + H_2O$ An optional extension of this concept is to examine the role of buffers; e.g., antacids.	Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Le Chatelier's Principle" Chemistry Experiments and Principles Laboratory Manual Experiment, "Applying Le Chatelier's Principle" CAUTION: Chromate or dichromate salts are carcenogenic; barium salts are hazardous.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
11.0 Explain how an indicator works in an acid-base equilibrium.	The idea of an indicator behaving as a weak acid should be illustrated; e.g., addition of HCl, a strong acid, to $HLi_{(aq)} \rightleftarrows H^+_{(aq)} + Li^-_{(aq)}$ (Litmus) will shift equilibrium left. HLi is red. Demonstration of various indicators, both common and those found in a lab should be done.	Chemistry: A Modern Course "Indicators," 25.6 Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, " Finding [H^+] with Indicators" Chemistry: Experiments and Principles Laboratory Manual Experiment, "Determination of [H^+] Using Indicators" CAUTION: Some indicators such as methyl orange and indigo carmine are carcinogenic and can be absorbed through the skin.
12.0 Write mass action expressions for acid-base reactions.	For example, $HA_{(aq)} \rightleftarrows H^+_{(aq)} + A^-_{(aq)}$ $K_a = \frac{[H^+][A^-]}{[HA]}$	

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCE
) Differentiate between the magnitudes of various K_a's and strengths of acids.	Have students identify the stronger of two acids on the basis of their Ka's in a strength of acid table.	
) Solve problems in ionic equilibria using K_a's.	For example, students could calculate the $[H^+]$, $[X^-]$, $[OH^-]$, and $[HX]$, pH and percent dissociation of a 0.20 mol/L $[HX]$ solution.	

CHEMISTRY 300 TIME: 10-12 hours

D: **Solubility**

ONALE: This unit provides an introduction to the solubility of a solid and/or gas in liquids i terms of dynamic equilibrium and relates this concept to such science-technology-societ units as Analytical Chemistry, Metallurgy, and Environmental Chemistry.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
e student should be able to:		
Explain solubility in terms of a dynamic equilibrium.		Chemistry: A Modern Course Chapter 21 covers objective 1.0. Chapter 25 covers objectives 3.0, 4.0, 5.0 and 6.0. Objective 2 is not covered Chemistry Experimental Foundations, 3rd ed. All objectives are covered by Chapter 16.
.0 Describe the effect of temperature on the solubility of a solid in a liquid; and the solubility of a gas in a liquid.	Examples: 1. More sugar dissolves in hot coffee than in cold coffee. 2. Gases are more soluble in cold than in warm liquids; e.g., carbonated beverages (alcoholic and non-alcoholic).	Chemistry: Experiments and Principles Chapter 13 covers all objectives very superficially.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	3. Trout are found in cold rather than warm water because of the greater amount of oxygen dissolved in cold water.	
.0 Write Ksp expressions, given an equation.	Example: $Ca(OH)_{2(s)} \rightleftarrows Ca^{2+}_{(aq)} + 2\ OH^-_{(aq)}$ $Ksp = [Ca^{2+}][OH^-]^2$ $Ca_3(PO_4)_2 \rightleftarrows 3Ca^{2+}_{(aq)} + 2\ PO_4{}^{-3}_{(aq)}$ $Ksp = [Ca^{2+}]^3\ [PO_4{}^{3-}]^2$	
.0 Calculate the solubility in water of any singly ionized compound from its Ksp.	Have students calculate the solubility of $CuS_{(s)}$ in water in mol/L or g/L from Ksp. The procedure in the above is to be done only for a one-to-one ratio between the anion and the cation.	
.0 Calculate the Ksp from the solubility of a singly ionized compound (one-to-one ratio).	In a lab, have students determine the Ksp using a saturated $Ca(OH)_2$ solution. Titrate using 0.10 mol/L of hydrochloric acid. Use 150 mL and 20.0 mL samples of saturated calcium hydroxide (limewater). Use	Chemistry: Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Solubility Constant of Lead Chloride"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	eight drops of bromthymol blue as an indicator and titrate to first hint of yellow. Solve for data.	CAUTION: Lead and chromate salts are hazardous.
Make quantitative predictions based on calculations as to whether two solutions of known concentrations and volumes will or will not form a precipitate when mixed.	When equal volumes are mixed such as: 2.0×10^{-3} mol/L $Ba(NO_3)_2$ and 3.0×10^{-4} mol/L Na_2SO_4, will a precipitate of $BaSO_4$ form? Students should calculate the trial Ksp and compare to the given Ksp.	

CHEMISTRY 300

TIME: 16-18 hours

T E: Oxidation-Reduction

IONALE: This unit provides an introduction to electrochemistry and background which can be applied to such areas as metallurgy.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
he student should be able to:		
.0 Draw and label a functioning electrochemical cell given two substances for electrodes.	Either a teacher demonstration or a suitable student experiment on functioning cells should be done to provide a practical introduction for this activity.	Chemistry: A Modern Course All objectives in this unit are contained in Chapter 26, "Oxidation-Reduction" and Chapter 27 "Electrochemistry." Chemistry Experimental Foundations, 3rd ed. All objectives in this unit are contained in Chapter 18 "Oxidation-Reduction Reactions and Electrochemistry" and Appendix 8. Chemistry: Experiments and Principles All objectives in this unit are contained in Chapter 15, "Oxidation and Reduction."

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Electrochemical Cells" CAUTION: Lead salts ar highly toxic.
2.0 Identify a reaction as an oxidation-reduction equation by determining electron transfer.		
3.0 Identify the substance oxidized, substance reduced, the oxidizing agent, and the reducing agent in any oxidation-reduction reaction.		
4.0 Use data from experiments to rank various substances in ability to compete for electrons.	Demonstrations or experiments should be done to illustrate the ability of some substances to remove electrons from others. In Chemistry a Modern Course, the experiment, "Oxidation-Reduction Reactions," could be demonstrated to illustrate a variety of different reactions not covered in some experiments.	Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "An Introd tion to Oxidation-Redu tion" Chemistry: Experiments and Princples Laborato Manual Experiment, "An Introd tion to Oxidation-Redu tion"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
5.0 Predict the ability of reactions to occur using a table of reduction potentials.		
6.0 Balance oxidation-reduction equations using oxidation numbers or a table of half-reactions.		
7.0 Draw and label an electrolysis cell.	A demonstration of a cell by the teacher would be useful in illustrating this objective.	
8.0 Solve problems using Faraday's laws of electrolysis.	Problems to be solved should include the following. i) Given a quantity of materials deposited at one electrode, determine the quantity deposited at another. ii) Given the amperage and the time of electrolysis, calculate the amount of material deposited at any electrode. Demonstrations and experiments should be used to extend this objective and to provide practical applications of it.	Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Electrolysis of Aqueous Potassium Iodide" Experiment, "Relationship Between Moles of Copper and Moles of Electrons Involved in Electrolysis" Chemistry: Experiments and Principles Laboratory Manual Experiment, "Electroplating Lead," Experiment, "The Electrolysis of Aqueous Potassium

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Iodide"
Apply oxidation-reduction theory to lab-related activities.	Some experiments should be attempted here to show the variety of oxidation-reduction reactions and to illustrate some practical applications; e.g., sacrificial metals to prevent corrosion.	Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Corrosion of Iron," Experiment, "Reactions Between Ions in a Solution"
	Some enrichment may be attempted here with an oxidation-reduction titration such as an experiment in Chemistry: A Modern Course, "Quantitative Titration involving Redox Reactions" with Potassium permanganate and Iron(II) sulfate.	Chemistry: Experiments and Principles Laboratory Manual Experiment, "Corrosion of Iron," Experiment, "Reactions Between Ions in a Solution"

chemistry 300 (options)

CHEMISTRY 300 TIME: 10 hours

UNIT: Analytical Chemistry

RATIONALE: This unit is designed so that the student will be able to recognize the use of analytical chemistry and understand its importance when applied to research, industry, and the preservation of our environment. The unit is laboratory in approach, containing many activities which often are performed in industry. In all experiments, decisions about the nature of materials are based on experimental evidence.

PRIMARY REFERENCES:

1. Jenkins, F., et al. *ALCHEM: Analytical Chemistry*. Edmonton: J.M. LeBel, 1978.

OR

2. Toon, E., and Ellis, G. *Laboratory Experiments for Foundations of Chemistry*. SI ed. Toronto: Holt, Rinehart and Winston of Canada, 1978.

SUPPLEMENTARY REFERENCES:

1. Gordon, Glen, and Keifer, William. *IAC: The Delicate Balance: An Energy and the Environment Module*. New York: Harper and Row, 1980.

2. Parry, Robert W., et al. *Chemistry Experimental Foundations Laboratory Manual*. 3rd ed. Toronto: Prentice-Hall of Canada, 1982.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to: 1.0 Test unknown solutions by means of:		
1.1 Qualitative Analysis: Cations	For the ALCHEM laboratory activity, students should test for ammonium cations using potassium monohydrogen phosphate in step ten of "cation analysis" to prevent the introduction of extraneous sodium ions.	*ALCHEM: Analytical Chemistry* Experiment, "Cation Analysis"
1.2 Qualitatative Analysis: Anions	Students should do an anion analysis on a solution. For safety reasons, teachers may wish to eliminate testing for NO_3^-. TTE (1,1,1- Trichlorotrifluoroethane) can be used as a substitute for carbon tetrachloride. CAUTION: Use care in handling concentrated acids.	*Laboratory Experiments for Foundations in Chemistry* Experiment, "Qualitative Analysis" CAUTION: Oxalates are corrosive to tissue, and chromates are carcinogenic. Use care with concentrated acid. *Chemistry Experimental Foundations Laboratory Manual*, 3rd ed. Experiment, "Qualitative Analysis" *ALCHEM: Analytical Chemistry* Experiment, "Anion Analysis"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
1.3 Quantitative Analysis	Students should do volumetric analysis in determining amounts of ions in solutions.	ALCHEM: Analytical Chemistry Experiment, "Volumetric Analysis for ASA" CAUTION: Oxalic acid is highly corrosive. Use care with any concentrated acids. Laboratory Experiments for Foundations of Chemistry Experiment, "Percent of Silver," Experiment, "Standardization of Acid and Base Solution," Experiment, "Analysis of Commercial Products" Chemistry Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Quantitative Titration" IAC: Delicate Balance Experiment, "How Hard is Water?"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
1.4 Colorimetric Analysis	Students should determine the strength of a solution by comparing its color to that of a standard solution.	IAC: Delicate Balance Experiment, "Phosphate in Water and Detergents" CAUTION: Ammonium molybdate may burn the skin. Use care with concentrated acids.
1.5 Gravimetric Analysis	Students should use the gravimetric method in determining the amount of an ion in a sample.	ALCHEM: Analytical Chemistry Experiment, "Gravimetric Analysis for Copper" CAUTION: Use care with concentrated sulfuric acid. Laboratory Experiments for Foundations of Chemistry Experiment, "Percentage Purity of a Sample of Silver" CAUTION: Use care with concentrated nitric acid.
2.0 Relate analytical chemistry to application in technology, water management and other potential careers.	In a class discussion, make students aware of the use of analytical chemistry in such industries as mining and petroleum, in the production of fertilizers and in the analysis of water pollution. Discuss the use of	

BJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	sophisticated equipment to measure concentration in parts per million or lower.	

CHEMISTRY 300 TIME: 10 hours

UNIT: Metallurgy

RATIONALE: This unit is designed to help students gain a basic knowledge of (a) the extraction and refining metals, (b) the corrosion of metals, and (c) the effect of these processes on the environment and potential ways to minimize negative effects. Objective 6, which is concerned with trade-offs related to the metal industry, is an extension within this design.

PRIMARY REFERENCES:

1. Jenkins, F., et al. ALCHEM: Metallurgy and Corrosion. Edmonton: J.M. LeBel, 1979.

OR

2. Worthington, Graham. Chemistry of Metallurgy. Agincourt, ON: The Book Society of Canada, 1980.

SUPPLEMENTARY REFERENCES:

1. Curren, T., et al. Still Waters: The Chilling Reality of Acid Rain. Ottawa: Minister of Supply and Services, 1981. This title is a report to the Sub-Committee on Acid Rain, House of Commons.
2. Environment Canada. Downwind: The Acid Rain Story. Ottawa: Information Directorate, Environment Canada, 1982.
3. Johnston, A.H., ed. Titanium: The Aerospace Metal, The Amsyn Problem, and Zinc and You. Glasgow, Scottish Council for Educational Technology, 1980. (These simulations are useful in developing objectives 6.0 and 6.1.)
4. Kelly, Tom. How Many More Lakes Have to Die? Ottawa: Information Services. Ministry of the Environment, 1981.
5. Ministry of the Environment. The Case Against Acid Rain. Toronto: Information Services Branch, Ministry of the Environment, 1982.
6. Nevill, W.A. General Chemistry. Toronto: McGraw-Hill Book Company. 1976.

7. Routh, et al. *A Brief Introduction to General Organic and Biochemistry*. Toronto: W.B. Saunders, 1971.

8. Turk, et al. *Introduction to Chemistry*. New York: Academic Press, 1968.

AUDIO-VISUAL RESOURCES:

1. Films are available from Noranda Mines Limited, P.O. Box 45, Commerce Court West, Toronto, Ontario, M5L 1B6.

   - To Make the Wasteland Green
   - Strategy for Change
   - Noranda's Continuous Smelting Process
   - The Unending Search
   - We Live in Mining

2. Sample kits are available from Alcan Public Relations Services, 1 Place Ville Marie, Montreal, Quebec, H3C 3H2.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
he student should be able to:		
.0 Describe how some of the common metals are extracted from ore.	Students should be made familiar with the roasting of sulphides and carbonates using equations. Illustrate the above by demonstration and lecture; e.g., separation of ore from gangue. Discussion of the flotation method is found in the ALCHEM modules. Basic oxygen furnace and electric arc furnace are two present day methods of roasting.	ALCHEM: Metallurgy and Corrosion "Roasting the Ore" Experiment, "Roasting of Carbonate Ore"
.0 Describe the process of reducing metals from their oxides.	Students should write equations illustrating reduction of oxides of common metals; e.g., zinc, iron, aluminum, and copper.	ALCHEM: Metallurgy and Corrosion "Reducing the Metal" Experiment, "Reduction of a Metal" Chemistry of Metallurgy Experiment, "Reduction of an Oxide with Hydrogen," Experiment, "Reduction with Carbon"
.0 State how metals are refined.	Students should write equations illustrating the procedure of refining metals; e.g., conversion of blister copper (99.5% pure) to copper (99.75% pure) by electrolysis.	ALCHEM: Metallurgy and Corrosion "Refining the Metal"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry of Metallurgy "Corrosion" Experiment, "Corrosion of Iron"
.0 Describe the process of metal corrosion.	Students should know how metals such as iron or copper will corrode in oxygen, and in reaction with acid rain.	Chemistry of Metallurgy, "Corrosion" Chemistry: Experimental Foundations Laboratory Manual, 3rd ed. Experiment, "Corrosion of Iron" CAUTION: Potassium dichromate is carcinogenic Chemistry: Experiments and Principles Laboratory Manual Experiment, "Corrosion of Iron"
.0 State methods of preventing corrosion.	Use a demonstration to help students become familiar with methods of preventing corrosion such as (i) alloying, (ii) coating (galvanizing; using paint or plastic) and (iii) electroplating.	ALCHEM: Metallurgy and Corrosion Teacher demonstrations, "Prevention of Corrosion," "Protective Coatings" Chemistry of Metallurgy "Zinc and Lead" "Alloying"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
ENSION		
0 Describe the trade-offs necessitated by the process of making metals from raw materials. 6.1 Describe technological means for decreasing negative environmental effects.	Students should be aware of devices that industries use to minimize the level of pollution emitted into the air and water (scrubbers, electrostatic precipitators; e.g., Cottrel, settling reservoir). Students should be aware of factors which are considered in such problems as acid rain. Discussions, debates, or research papers would be useful.	Amsyn Problem Downwind: The Acid Story Still Waters: The Chilling Reality of Acid Rain

CHEMISTRY 300 TIME: 10-15 hours

UNIT: Consumer Chemistry

RATIONALE: This unit introduces the student to some common chemicals in the environment outside the classroom. It attempts to develop an awareness in the student of means for comparing consumer products. This is accomplished by testing, collecting data, and analyzing products. This unit applies chemical principles to materials found in the home rather than the laboratory. It also promotes some understanding of the interdependence of human material comfort and the trade-offs which may be necessary in order to achieve a certain lifestyle.

To fulfill the objectives of this unit, a teacher could select Chemistry for Changing Times and one or more of the laboratory manuals. A second option would be to use Consumer Science: Text and Laboratory Manual. The textual material, however, is limited for this second option. A third option would be to use one or more of the Unigraph Modules which contain some brief theory and laboratory activities. These are reproducable for class use.

PRIMARY REFERENCES:

TEXTS:

1. Hill, J.W., et al. Chemistry for Changing Times. Minneapolis: Burgess, 1980.

OR

2. Kowalski, Stephen, W. Consumer Science: Text and Laboratory Manual. Minneapolis: Burgess, 1981.

LABORATORY MANUALS:

1. Eby, D., and Tatum, R. The Chemistry of Soap, Detergents, and Cosmetics. Seattle: Unigraph, 1978.
2. ----------. The Chemistry of Beverages. Seattle: Unigraph, 1978.

3. ----------. The Chemistry of Food. Seattle: Unigraph, 1977.

4. ----------. The Chemistry of Food Additives. Seattle: Unigraph, 1978.

6. ----------. The Chemistry of Over-the-Counter Drugs. Seattle: Unigraph, 1978.

5. Summerlin, Lee. Chemistry of Common Substances. Morristown, NJ: Silver Burdett, 1979.

SUPPLEMENTARY REFERENCE:

1. #Stine, W.R. Applied Chemistry. 2nd ed. Toronto: Allyn and Bacon, 1981.

# "Consumer Chemistry" entails a great deal more than 10 hours; therefore, some selection is necessary. Your selection may be influenced by what was done in Chemistry 200 in the unit "Food Additives" and/or "Drugs." If one or both of these units were completed in Chemistry 200, the theory should not be repeated at this time.

Some possible combinations of objectives that would make a 10-12 hour unit might be: 1) objectives 1.1, 1.2, 1.3, 2.0, 3.1, and 3.2 which entail the preparation and testing of soaps, detergents, and cosmetics; 2) objectives 4.1, 4.2, 4.3, and 5.0 which entail the analysis and comparison of foods and food additives; 3) objective 6.0 which entails the comparison of some over-the-counter drugs which would have to be supplemented with theory from the drug unit in Chemistry 200 (This should only be done by itself if drugs were not attempted in Chemistry 200.); 4) objectives 1.1, 1.2, 2.0, 3.1, and 6.0 which entail the preparation and testing of soap and detergents and the testing of over-the-counter drugs. The teacher can select other alternatives to fullfil his/her own objectives.

# This book would serve as an excellent teacher reference.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
The student should be able to:		
1.0 Describe how common chemicals can be combined to make consumer products.		Chemistry for Changing Times "Household Chemicals: Helps and Hazards,"Chapter 20
1.1 Describe the formation of soap.	An experiment on the preparation of soap can be done here. CAUTION: Solid sodium hydroxide burns the skin.	Chemistry of Soap, Detergents and Cosmetics Experiment, "From Drain Cleaner to Soap" Chemistry of Common Substances Experiment, "Preparing Soap"
1.2 Describe the formation of detergents.	An experiment on the preparation of a detergent can be done. CAUTION: Use care with concentrated sulfuric acid.	Chemistry of Common Substances Experiment, "Preparing Dreft - A Detergent"
1.3 Prepare various cosmetics.	Some preparation of various cosmetics can be done to determine what chemicals a cosmetic contains, what they do, and why they are there.	Chemistry for Changing Times "Cosmetics: The Chemistry of Charm," Chapter 21 Chemistry of Soap, Detergents and Cosmetics Experiment, "Project - Cold Cream"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Experiment, "Project - Shaving Cream" Experiment, "Miniproject- After Shave Lotion" Experiment, "Project - Toothpaste" Chemistry of Common Substances Experiment, " Making Hand Lotion" Experiment, "Preparing Cleansing Cream" Experiment, "Personal Care Chemistry"
2.0 Identify the properties of soaps and detergents.	Some experiments should be done to illustrate the properties and use of soap. CAUTION: Chlorinated hydrocarbons are carcinogenic.	Chemistry of Soap, Detergents, and Cosmetics Experiment, "Detergent Detective" Consumer Science Experiment, "Hardness of Water" Chemistry of Common Substances "Investigating Hard and Soft Water"
3.0 Compare chemical products on a cost-effective basis.		

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
3.1 Compare and rate soaps and detergents on a cost-effective basis.	Some experiments rating the effectiveness of soaps and detergents using selected criteria should be attempted. CAUTION: Acetic anhydride and concentrated sulfuric acid can cause severe burns.	Chemistry of Soap, Detergents, and Cosmetics Experiment, "Getting Your Money's Worth" Consumer Science Experiment, "Harshness of Soap" Experiment, "Soap Adulterate" Experiment, "Water Content of Soap" Experiment, "Scouring Powders"
3.2 Rate cosmetics according to pre-selected criteria.	Experiments can be done to rate various types of cosmetics on criteria specific to each type of cosmetic.	Consumer Science Experiment, "Toothpaste" Experiment, "Mouthwash" Experiment, "Shampoo"
0 Describe the components of food in qualitative and quantitative terms.		Chemistry for Changing Times "Food: Those Incredible Edible Chemicals," Chapter 16
4.1 Analyze foods qualitatively for some of their components.	Some experiments can be done to identify components of food. CAUTION: Chlorinated hydrocarbons are hazardous to health.	Chemistry of Food Experiment, "Some Nutrients in Milk"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	CAUTION: Concentrated sulphuric and nitric acid can cause severe burns. Alpha napthol can be absorbed through the skin.	Chemistry of Beverages Experiment, "Sugar in Orange Juice" Chemistry of Common Substances Experiment, "Testing for Carbohydrates" Experiment, "Tests for Protein" Experiment, "Testing for Starch" Experiment, "Potassium in Coffee and Tobacco"
4.2 Analyze foods quantitatively for their components.	Foods can be analyzed on a quantitative basis to determine the level of the component present.	The Chemistry of Food Experiment, "How Fat is the Fat" CAUTION: Clorinated hydrocarbons are carcinogenic. The Chemistry of Beverages, Experiment, "Testing of Milk for Calcium" CAUTION: Concentrated acids and bases and ammonium oxalate may burn skin.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry of Common Substances Experiment, "The Mineral Content of Milk" Experiment, "Determining the Iron Content of Food" Experiment, "Testing for Vitamin C in Foods" Experiment, "Are Your French Fries Greasy?" Experiment, "Fat Content of Milk" Experiment, "Fat Content of Ground Beef" CAUTION: Chlorinated hydrocarbons are hazardous to health.
4.3 Compare food products on a cost-effective basis.	Some experiments can be done to compare food products on a cost-effective basis.	Chemistry of Food Additives Experiment, "A Hot Dog--What's in it For Me?" CAUTION: Chlorinated hydrocarbons. Consumer Chemistry Experiment, "Coffee" Experiment, "Tea" NOTE: The caffeine extraction with chloroform should be omitted.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
Analyze food for some selected food additives.	Experiments can be done to identify some food additives present in food. If the unit on food additives was not attempted in Chemistry 200, this objective could be expanded to include the role of various additives in food.	Chemistry for Changing Times "Food Additives: Bane or Blessing?" Chapter 17 Chemistry of Food Additives Experiment, "Calcium Propionate in Bread" Experiment, "Analysis of Fruit Juice for Vitamin C" Chemistry of Common Substances Experiment, "Sulfur Dioxide in Foods" CAUTION: Barium salts may be hazardous. Wash hands thoroughly. CAUTION: Chloroform is banned from use. Experiment, "Detecting Calcium Propionate in Bread" Experiment, "Benzoic Acid and Sodium Benzoate in Food"
Analyze and compare various analgesics and antacids on a cost-effective basis.	Some experiments on the comparison of types of over-the-counter drugs may be done. If the unit on drugs was not done in Chemistry 200, then some of the chemistry should be in-	Chemistry for Changing Times "Body Chemistry: Drugs-from Colds to Cancer," Chapter 22

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	cluded in the study of this unit.	Chemistry of Over-the-Counter Drugs Experiment, "Neutralizing Excess Stomach Acid" Experiment, "An Aspirin Lab" Consumer Chemistry Experiment, "Antacids" Chemistry of Common Substances Experiment, "Testing Antacid Tablets"

UNIT: Environmental Chemistry

RATIONALE: This unit is designed so that the student will gain a) an appreciation of the interaction between man, technology and his environment; b) an understanding of the interdependence of human material comfort and pollution and the inevitable trade-off between them; c) an ability to use scientific explanations to solve a problem; d) an appreciation for the finiteness of the water supply; e) an awareness of alternative solutions to environmental problems and; f) an understanding of the limits of scientific knowledge relative to the solution of present problems and of the difficulty of preventing unforeseen side effects as a result of efforts to control imperfectly understood natural processes. This unit can be done in two parts: air or water. Each part is 10 hours in length. A teacher may wish to do both parts in order to complete the two-unit science-technology-society requirements for Chemistry 300.

PRIMARY REFERENCES:

1. Hamill, J. Water, Chemistry and Ecology. Agincourt, ON: The Book Society of Canada, 1979.

OR 2. Hill, J.W., et al. Chemistry for Changing Times. Minneapolis: Burgess, 1981.

OR 3. Gordon, Glen, and Kiefer, William. IAC: The Delicate Balance. New York: Harper and Row, 1980.

SUPPLEMENTARY REFERENCES:

1. Chemecology. Washington, D.C.: Chemical Manufacturers Association. This periodical is available free upon request.

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Environment Canada. Downwind: The Acid Rain Story. Ottawa: Information Directorate Branch, Canada, 1982.

- Still Waters: The Chilling Reality of Acid Rain. Ottawa: Minister of Supply and Services, 1981. (This is a report to the Sub-committee on acid rain, House of Commons)
- How Many More Lakes Have to Die? Ottawa: Information Directorate, Environment Canada, 1981.

Health and Welfare. Acid Rain, Air Pollution and Your Health. Ottawa: Information Directorate, Health and Welfare Canada, 1980.

Manitoba Department of Education. Fossil Fuels. Winnipeg: The Department, 1982.

Ministry of the Environment. The Case Against Acid Rain: A Report on Acidic Precipitation and Ontario Programs for Remedial Action. Toronto: Ministry of the Environment, 1980.

Reid, N. The Amysn Problem. Glasgow: The Scottish Council of Educational Technology, 1978. (This simulation is useful in developing objective 12.0 for Water Pollution or it can be used in other options such as Metallurgy.)

7. Webb, M. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W.B. Saunders Company Canada Limited, 1980. Only one copy of The Canadian Environment is needed and should be used in conjunction with any of the above textual materials.

8. Stine, W.R. Applied Chemistry: 2nd edition. Toronto: Allyn and Bacon, 1981.

9. Vallarino, L.M., and Quagliano, J.V. Chemistry: A Humanistic Approach. New York: McGraw-Hill, 1975.

AUDIO-VISUAL REFERENCES:

1. Department of Education, Instructional Media Services
   - The Rival World
   - How Safe is Enough?
   - NOVA: The Insect Alternative (also useful in unit on food production)

2. Information Directorate, Health and Welfare Canada, Ottawa, K1A 0K9.
   - What's in the Wind? (a 17 minute video-tape which is available on a loan basis)

3. A video-tape entitled "What's in it for Me?" is available on loan from Information Directorate, Health and Welfare Canada, Ottawa, K1A 0K9.

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
PART I: WATER CHEMISTRY The student should be able to:		
1.0 Recognize the quality and the finiteness of the supply of drinking water, its distribution around the world, and the need to conserve.	Students should examine graphs which indicate the distribution and rate of use of water. As a related activity, the teacher may examine a sample of water for coliform count. CAUTION: Culturing bacteria requires precautions.	Water, Chemistry and Ecology "Water in Your Life," Experiment, "Counting Bacteria" The Delicate Balance "Water, Water, Everywhere" Chemistry for Changing Times, 3rd ed. "A Drop to Drink"
2.0 Describe the interrelationships and balance within an ecological cycle and how man has intervened in this cycle.	Students should examine the ecological and suggest ways in which this cycle can be altered, both through natural causes (e.g., volcanic eruption), or human activities (e.g., pollutants).	Water, Chemistry and Ecology "Water and Life Cycles" The Delicate Balance "Our Environment: What is the Balance," "The Water Environment" Chemistry for Changing Times, 3rd ed. "A Drop to Drink" The Canadian Environment: Data Book on Energy and Environmental Problems "Acid Rain," "North American

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Lakes That are Sensitive to Acidification by Acid Precipitation"
3.0 Describe temporary and permanent hardness in water and how it can be measured and controlled by water softening.		*Water, Chemistry and Ecology* "Domestic Water" Experiment, "Estimating Total Hardness" Experiment, "Action of an Ion Exchange Column" (Ion exchange resins are available at common supply houses.) *The Delicate Balance* Experiment, "How Hard is Water" *Chemistry for Changing Times,* 3rd ed. "Natural Water Isn't all Water," Chapter 18 "Water Softness," Chapter 20
4.0 Differentiate between a soap and a detergent and describe the action of detergency.	Have students use colorimetric standards of phosphates to determine phosphate concentration in water.	*Water, Chemistry and Ecology* "Action of Soap in Hard Water," "Synthetic Detergents: A Mixed Blessing"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	CAUTION: Ammonium molybdate may be hazardous to health if inhaled or ingested. Use care with concentrated sulfuric acid.	The Delicate Balance "Why Phosphates in Detergents?" "Ring Around the Bathtub" Experiment, "Phosphates in the Water" Experiment, "How Hard is Water?" Chemistry for Changing Times, 3rd ed. "Grandma's Lye Soap" to "Brighter than Bright," Chapter 20
5.0 Describe the effect of phosphates on the phosphorous cycle and how their presence can lead to eutrophication.	As an alternative activity, students could examine the nitrogen cycle and the effect of humans and their waste on the cycle.	Water, Chemistry and Ecology "Phosphorus and Phosphates" "Water and the Nitrogen Problem" Experiment, "Growing Algae Blooms" The Delicate Balance "Eutrophication and Over-Fed Lakes" to "Putting Algae on a Diet" and "Detergents--the Phosphate Dilemma" Chemistry for Changing Times "Detergent Formulations: Phosphates," Chapter 20

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		The Canadian Environment: Data Book on Energy and Environmental Problems "Nitrates and Phosphates"
6.0 Compare the advantages and disadvantages of alternatives to phosphates in detergents.	Both chemical, health, and potential economic effects could be listed and examined. A discussion of the concept of risk such as the estimated frequency or probability of death or injury. The film "How Safe is Enough" is useful and also can be done with objective 11.0 or 12.0.	Water, Chemistry and Ecology "Biochemical Oxygen Demand" Experiment, "Five Day BOD" The Delicate Balance "Detergents: The Phosphate Dilemma" Chemistry for Changing Times, 3rd ed. "Laundry Detergent: Formulations," Chapter 20
7.0 Measure biochemical oxygen demand (BOD). 7.1 Describe ways of lowering BOD in waste waters.	Relate the increase of wastes to increased levels of biochemical oxygen demand.	The Delicate Balance "Out of Sight--Not out of Circulation" to "Lowering the BOD" Experiment, "Testing the BOD" Chemistry for Changing Times "Sewage: Some Chemistry and Biology," Chapter 18

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		The Canadian Environment: Data Book on Energy and Environmental Problems "Bacteria in Fresh Water"
8.0 Describe primary, secondary, and tertiary sewage treatment.	The teacher may wish to build a model of a sewage treatment plant with the class or visit the local water treatment facility.	Water, Chemistry and Ecology "Sewage and Water Treatment" Experiment, "Flocculation" The Delicate Balance "Lowering the BOD" Chemistry for Changing Times, 3rd ed. "Waste Water Treatment Plants" to "A Drop to Drink," Chapter 18
9.0 Compare the role of sewage lagoons, anaerobic bacteria, activated sludge process, chlorination and desalination in water treatment.	The teacher may wish to examine pamphlets from Greater Winnipeg Water Works on sewage treatment.	Water, Chemistry and Ecology "Sewage and Water Treatment" Experiment, "Chlorination" Experiment, "Distillation of Salt Water" The Delicate Balance "Lowering the BOD" Chemistry for Changing Times "Waste Water Treatment Plants," Chapter 28

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
10.0 Describe other pollutants and their effect on the environment and on people.	Consider such pollutants as Hg, As, pesticides, dioxins, PCB's and other heavy metals. Readings from sources such as Applied Chemistry, Chemistry for Changing Times and other sources can be assigned for reporting purposes.	Water, Chemistry and Ecology "Industrial Pollution" Experiment, "Sulfite Pollution" The Delicate Balance "The Pyramid of Life" to "Pesticides--Where Did the Birds Go" Chemistry for Changing Times, 3rd ed. "Contamination by Toxic Substances" to "Heavy Metal Contamination," Chapter 18 The Canadian Environment: Data Book on Energy and Environmental Problems "Polychlorinated Biphenyls," "Mercury," "Lead," and "Pesticides"
11.0 Compare the pros and cons of attempting to remove completely pollutants such as pesticides and PCB's from the environment.	Identify some articles on the pros and cons of eliminating pollution and conduct a class discussion on the subject. The Amsyn Problem represents one approach to this.	The Delicate Balance "Shall the Bugs Take Over?" and "Carcinogens in Our Environment" Chemistry for Changing Times "An End to Water Pollution" The Amsyn Problem

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
EXTENSION		"The Insect Alternative" (film)
12.0 Identify the significant elements and implications of industrially producing a new product upon the environment and economy of a town. Significant elements include alternative scientific technological means for removing pollutants and their costs. . Identify relationships among the elements of an issue and their relative importance. . Distinguish among facts, opinions, beliefs and value judgements used in reaching a decision. . Evaluate and present information about the issue of new, industrial production and its effect upon the environment and the people.		The Amsyn Problem "How Safe is Enough?" (film)

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
Part II: Air Chemistry The student should be able to: 1.0 Identify sources of acid rain and smog (e.g., SO_2 and NO_2).		The Delicate Balance "Airing the Problem" to "pH of Rainfall" and "Photochemical Smog" Experiment, "Sulfuric Acid in Action" Experiment, "pH of Rainfall" Experiment, "NO_2 Ways About It"
1.1 Describe the chemical mechanisms whereby they become acid rain.	Demonstrations of the effects of acids on various substances such as a marble can be used to illustrate acid effects.	Chemistry for Changing Times, 3rd ed. "Doomsday in Donora" to "Sulfur Oxides" and "Los Angeles Smog" to "The Ozone Layer," Chapter 18
1.2 Describe the effects of acid rain and smog on human beings, animals, plants, steel, and stone.		The Canadian Environment: Data Book on Energy and Environmental Problems "Acid Rain" and "Air Pollution"
2.0 Compare methods of limiting the concentration of acid rain and smog in the environment and their costs.		The Delicate Balance "Can Anything be Done?" The Still Waters: The Chilling Reality of Acid Rain How Many More Lakes Have to Die?

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Chemistry for Changing Times, 3rd ed. "What to do About London Smog," "Who Pollutes? How Much?" and "What to do About Air Pollution"
3.0 Describe the role of tetraethyl lead in gasoline, its effect on the environment and alternatives to its use.	Test for lead by using about ten litres of water obtained from snow beside a road. Use potassium chromate in the test. CAUTION.	The Delicate Balance "Lead as an Air Pollutant" Experiment, "Lead Ashtray" Experiment, "Lead in Your Home"
3.1 Describe the operation of a catalytic converter in reducing air pollution and the reasons for removing lead from gasoline. Compare the effectiveness of the catalytic converter in removing pollutants to other alternatives.		Chemistry for Changing Times "Upping the Octane Rating," Chapter 10 The Canadian Environment: Data Book on Energy and Environmental Problems "Lead" The Delicate Balance "Unclean at Any Speed?" and "Cleaner Power for Autos" Chemistry for Changing Times, 3rd ed. "Get the Lead Out," Chapter 19 Fossil Fuels

CHEMISTRY 300 TIME: 10-15 hours

UNIT: Chemistry of Food Production

RATIONALE: This unit introduces students to the chemical principles employed in growing food. These principles are important whether they are applied to modern methods of farming or gardening. The application of new discoveries in science and technology has helped agriculture to increase yields over the past century and has helped to feed a larger world population; however, the application of the technologies and modern agricultural methods has also had some environmental effects. This unit should help students to examine both the advantages and disadvantages of alternative methods of food production. For example, the use of chemical pesticides alone can be compared to integrated approaches to insect control in regard to relative advantages and disadvantages. This unit can be examined as a whole within about 10-15 hours. An alternate approach would be to examine insect and weed control or soils and fertilizers in greater depth. The latter approach could satisfy the science-technology-society requirements of approximately 20-30 hours.

PRIMARY REFERENCES:

#1. Hill, J.W., et al. Chemistry for Changing Times: 3rd ed. Minneapolis: Burgess, 1980.

OR

#2. Stine, W.R. Applied Chemistry. 2nd ed. Boston: Allyn and Bacon, 1981.

OR

3. Bentley, C.F., and Robertson, J.A. Soils and Fertilizers for Gardens and Lawns. Edmonton: University of Alberta, 1977. A single copy for the teacher can be used in conjunction with supplementing pamphlets from Agriculture Canada and the Manitoba Department of Agriculture.

# Some simple laboratory activities can be obtained by using single copies of From Nature to Man or The Chemistry of Soil and Fertilizers. An additional useful reference for teachers is Bentley, C.F. and Robertson, J.A. Soils and Fertilizers for Gardens and Lawns. See reference three. The Canadian Environment: Data Book on Energy and Environmental Problems is very useful.

SUPPLEMENTARY REFERENCES:

1. Agriculture Canada. *Let's Talk About Pesticides*. Ottawa: Information Services, Agriculture Canada.
   - *Pesticides: Their Implications for Agriculture*
   - *Home Lawns*
   - *Soil Erosion by Wind*
   - *Soil Erosion by Water*
   - *Management of Saline Soils*
   - *What You Should Know about Soils*, Publication 1338
   - *Manures and Compost*, Publication 868
   - *Composting*, Publication 1681/E

2. Barrett, Bruce, and Stratton, John. *From Nature to Man*. Toronto: Wiley of Canada, 1976.

3. Bentley, C.F., and Robertson, J.A. *Soils and Fertilizers for Gardens and Lawns*. Edmonton: Faculty of Agriculture and Forestry, University of Alberta, 1977.

4. Department of Entomology (U of M) and Entomology Divsion (Agriculture). *Mosquitoes*. Winnipeg: Queens Printer, 1970.

5. Eby, D, and Tatum, R. *The Chemistry of Soil and Fertilizers*. Seattle: United Graphics, 1977.

6. Faculty of Agriculture. *Principles and Practices of Commercial Farming*, 5th ed. Winnipeg: Faculty of Agriculture, University of Manitoba, 1977.

7. Jarvis, B., and Mazzocchi, P. *IAC: Form and Function*. New York: Harper and Row, 1978.

8. Johnston, A.H., ed. *Nitrogen for the Nineties*. Glasgow: Scottish Council for Educational Technology, 1980. (This simulation is useful for developing objective 7.0 for Soil and Fertilizers.)

9. Knipling, E.T. *The Basic Principles of Population Suppression and Management*. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1979.

10. Manitoba Department of Agriculture. Manitoba Soils and Their Management. Winnipeg: Manitoba Department of Agriculture.
    - Manitoba Insect Control Guide
    - Weed Control for Home Grounds
    - Insects and Mites of Manitoba
    - Fertilizer Recommendations for the Home Garden
    - Manitoba Agriculture Farm Facts
        : Phosphorus Application for Annual Crops
        : Micronutrients in Crop Production
        : Phosphorus Fertilization in Crop Production
    - Grasshopper Control in Manitoba
    - Insect Control in the Home
    - Insect Control on Field Crops
    - Insect Control on Fruit Plants

11. Manitoba Department of Education. Agriculture: Source Comparisons (Pest Control, Organic and Conventional Farming). Winnipeg: The Department, 1984.

12. Organic and Conventional Farming Compared. Ames, IA: Council for Agriculture Science and Technology, 1980.

13. Webb, Madelyn. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W.B. Saunders, 1980. This book is very useful in a number of areas: data for pesticides, energy and use, and metal use.

AUDIO-VISUAL RESOURCES:

1. The Insect Alternative

2. Food or Famine

3. The Rival World

Available from the Department of Education, Instructional Media Services.

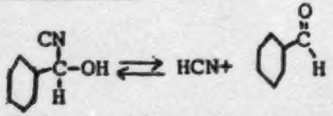
OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
I: SOILS AND FERTILIZERS		
student should be able to:		
Describe the component parts and properties of soils. Describe the general principles of soil formation and distribution in Manitoba.	The nature of soil and soil as a resource base in North America is part of the new Social Studies 100 and 101 courses. Teachers may only need to review the first two objectives. If students have not studied this section, teachers may wish to discuss the distribution of air, water, and various components in soils and/or do a soil profile. The water capacities of different soils can be measured.	Applied Chemistry "How Does Your Garden Grow," Chapter 12 Manitoba Soils and Their Management "Soils" From Nature to Man Experiment, "Chemicals in the Soil" Soils and Fertilizers: For Gardens and Lawns "Composition of Soil"
Relate plant growth and plant nutrition to dependency on such properties as:		
3.1 the essential nutrients and the ways whereby the nutrients are absorbed by the plants.	The essential nutrients range from macronutrients such as carbon and nitrogen which are essential for the production of amino acids, to micronutrients such as manganese and zinc. Discuss the role and effects	From Nature to Man "Nutrients and Chemicals: Fertilizers," Chapter 8 Applied Chemistry "How Does Your Garden Grow?" Chapter 12

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	of a lack of some nutrients in soil and the form in which nutrients are absorbed; e.g., NO_3^- not N_2.	Chemistry for Changing Times "Farm Chemistry: Food for a Hungry World" Facts: Micronutrients in Crop Production Manitoba Agriculture Farm Facts: Phosphorous Application in Crop Production From Nature to Man Experiment, "Effects of Inorganic Fertilizers"
3.2 solubility, ion exchange and water capacity of soils.	The importance of the exchange reaction for plant growth can be discussed. This is developed in Manitoba Soils and Their Management "Cation Exchange Capacity." An absorption activity can be attempted.	From Nature to Man "Nutrients and Chemicals: Fertilizers," Chapter 8 Applied Chemistry "How Does Your Garden Grow?" Chapter 12 Manitoba Soils and Their Management "Soils" The Chemistry of Soils and Their Fertilizers "Absorption"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
3.3 pH of soils (acidity-basicity) and salinity.	A natural dye can be used to test homogenized soil samples for pH (compared to a set of pH standards). A discussion of the nature of saline soils and its causes can be based on information from Management of Saline Soils.	Applied Chemistry "How Does Your Garden Grow?" Chapter 12 Manitoba Soils and Their Management "Reaction (pH)" Chemistry of Soils and Fertilizers Experiment, "Make it Yourself pH Indicator" Experiment, "Balancing the pH" Soils and Fertilizers: For Gardens and Lawns "Chemical Improvement of Soil" Fertilizer Recommendations for the Home Garden Management of Saline Soils
4.0 Describe how to correct for alkalinity, acidity and salinity of soils.		Applied Chemistry "How Does Your Garden Grow?" Chapter 12 Manitoba Soils and Their Management "Special Soil Problems"

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Management of Saline Soils
.0 Classify soils and relate the classes to potential uses and limitations.	Soils can be discussed in terms of the limitations in growing various foods (productivity), pressures on land use, e.g., agriculture or other uses.	Manitoba Soils and Their Management "Soil Classification"
.0 Identify ways in which soil quality is degraded and methods whereby soil degradation can be prevented.	An activity can be attempted which investigates the leaching of soil by water. An ammonium test kit is useful for this. Short and long-term effects of uses of soils can be examined, as well as the effects on organic matter of burning stubble or straw. The means of preventing soil degradation that can be examined include methods of tillage, irrigating and fertilizing.	Applied Chemistry "How Does Your Garden Grow?" Chapter 12 Manitoba Soils and Their Management "Special Soil Problems" Soil Erosion by Water Management of Saline Soils Soil Erosion by Wind Soils and Fertilzers for Gardens and Lawns "Treatments for Poor Physical Condition" From Nature to Man "The Leaching Effect," 8.3 Nitrogen for the Nineties

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
7.0 Compare the advantages and disadvantages of organic and non-organic fertilizers relative to plant growth and maintenance of land.	Comparison of the effectiveness of various kinds of fertilizer application can be made. Some sources of information include Phosphorus Application for Annual Crops and the information on nutrients and nutrient forms listed across from objective 3.0. Agriculture: Some Comparisons--Pest Control; Organic and Conventional Farming has a section related to this objective.	Applied Chemistry "How Does Your Garden Grow?" Chapter 12 Manitoba Soils and Their Management "Soil Fertility and Fertilizer Practices" Manitoba Agriculture Farm Facts: Phosphorus Application for Annual Crops Fertilizer Recommendations for the Home Garden Organic and Conventional Farming Compared Chemistry for Changing Times "Farm Chemistry" From Nature to Man "Nutrients and Chemicals: Fertilizers" Agriculture: Some Comparisons -- Pest Control; Organic and Conventional Farming

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
PART II: INSECT AND WEED CONTROL The student should be able to: 1.0 Differentiate among the various classes of chemicals used to control insects.		
1.1 Identify and compare the mechanisms whereby natural chemicals are used in defense and communication.	Teachers can describe how the carbonyl group (c=o) is used in substitutions to produce defensive materials such as hydrogen cyanide from mandelonitrile found in the millipede Apheloria corrugata (see Form and Function).  mandelonitrile benzaldehyde Case studies of organisms which use other defensive chemicals such as the bombardier beetle (benzoquinone) and millipedes (hydrogen cyanide) can be examined. Similarly, the use of pheromones by insects can be examined; e.g., specificity of pheromones and its use in communication. Some potential principles of insect control can be introduced; e.g., insect	Form and Function "Aldehydes and Ketones" Applied Chemistry "Insect Control: Chemical Communication" Chemistry for Changing Times "Farm Chemistry: Food for a Hungry World" Agriculture: Some Comparisons --Pest Control; Organic and Conventional Farming From Nature to Man "Pesticides and Pest Control" Manitoba Insect Control Guide Insect Control on Field Crops

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
	attractants, repellents, spectrum chemicals, and hormones.	
1.2 Identify and compare some broad-spectrum insecticides in terms of: - toxicity; - residual toxicity; - biomagnification or concentration in the food chain; - method of action.	Examples of the chlorinated hydrocarbons (e.g., DDT, pyrethrin), organic phosphorous compounds (e.g., malathion, parathion) and carbamates might be compared. The concepts of dose, toxicity and residue levels should be developed so that students can appreciate scales of residues which might be biologically active. For example, p.p.m. of triazine (herbicidal) is biologically active in soils, and p.p.b. of some oganophosphorous insecticides are biologically active in water against mosquitos. Some insecticides persist in the environment over a long period of time (DDT). Some are toxic but rapidly degraded in the environment (organic phosphorous compounds). For safety, and other reasons, the student should become aware that insecticides can vary appreciably in their effects.	See references for 1.1
2.0 Describe the susceptible periods in the life cycle of an insect such as the grasshopper or mosquito.	In discussion, the concept of periods and kinds of vulnerability in an insect's life can be developed. The concept of controls such as juvenile hormones can be introduced.	Chemistry for Changing Times "Juvenile Hormones: Why Don't You Never Grow Up?" Insects and Mites of Manitoba

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
		Grasshopper Control in Manitoba Mosquitoes
3.0 Compare the advantages and disadvantages of various methods of controlling insects: - chemical controls (pesticides, pheromones, repellents, juvenile hormones); - genetic controls (sterilization); - insect-resistant crop varieties; - biological agents (parasites, microbial agents) - integrated control methods.	The concept of biological pyramids and the effect of broad spectrum insecticides can be examined by means of case studies. The film "The Rival World" and the NOVA program The Insect Alternative can be used to introduce the topic. The existence of alternatives, each with different strengths and weaknesses, should be stressed as should the adjustment of methods as more is learned about suppression of insects and the comparative effectiveness of methods of control. (Some methods are more effective for some insects than for others.) In addition, attention should be paid to local conditions and such factors as climate. The document Agriculture: Some Comparisons (Pest Control, Organic and Conventional Farming), is useful.	Chemistry for Changing Times "Farm Chemistry: Food for a Hungry World" Applied Chemistry "Insect Control: Chemical Communication" From Nature to Man "Ecology," "Pesticides and Pest Control" Let's Talk About Pesticides Insect Control in the Home Insect Control on Field Crops Insect Control on Fruit Plants Pesticides: Their Implica- for Agriculture Agriculture: Some Comparisons --Pest Control; Organic and Conventional Farming

OBJECTIVES	SUGGESTED ACTIVITIES	REFERENCES
WEED CONTROL		
1.0 Classify common herbicides and describe their general method of operation.	Discuss how herbicides affect plants in general. Choose two or three herbicides and examine the ways whereby they are effective.	Chemistry for Changing Times "Farm Chemistry: Food for a Hungry World" From Nature to Man "Pesticides and Pest Control"
2.0 Compare the advantages and disadvantages of different methods of weed control.	The advantages and disadvantages of the use of herbicides in zero tillage methods could be examined.	Home Lawns Weed Control for Home Grounds

appendices

APPENDIX A

ANNOTATED BIBLIOGRAPHY

CORE

1. Jenkins, Frank et al. ALCHEM 10; ALCHEM 20. Edmonton: J.M. LeBel Enterprises, 1982.

   The soft cover texts will develop most of the topics in Chemistry 200 core adequately. Some emphasis upon molar volume and the gas laws are included. Laboratory activities and questions are integrated into the text so that students can answer directly within the text. The reading level is satisfactory for the average chemistry student. A teacher's guide is available.

   ALCHEM: Ethylene and Its Derivatives, 1979, 44 pages.
   Analytical Chemistry, 1979, 36 pages.
   Metallurgy and Corrosion, 1979, 36 pages.
   Food and Its Analogs, 1979, 60 pages.

   These modules support a number of the options using a practical, activity-oriented approach. Some historical background, industrial applications and questions are provided where approapriate. A teacher's guide is available.

2. Whitman, R.L. et al. Chemistry Today, 2nd ed. Scarborough, ON: Prentice-Hall Canada, 1982.

   This text adequately develops the concepts in the Chemistry 200 core and provides practical applications for a number of topics. Some some options, such as the chemical industry, can be developed from the text. The text is easily read by the average Chemistry 200 student. A laboratory manual and teacher's guide is available.

   Whitman, R.L. et al. Chemistry Today Laboratory Manual: 2nd ed. Scarborough, ON: Prentice-Hall, 1982.

   This laboratory manual contains a number of short laboratory activities. The activities generally use relatively inexpensive materials and provide appropriate cautions.

3. O'Connor, Paul et al. Chemistry Experiments and Principles. Toronto: D.C. Heath and Company, 1982.

   This most recent revision of the former CHEMS text includes additional material on descriptive chemistry that illustrates chemical principles and applications of the technologies. The core topics in Chemistry 200-300 are developed adequately. The reading level is satisfactory for the average, Chemistry 200 student. A teacher's guide is available.

   O'Connor, Paul, et al. Laboratory Manual for Chemistry Experiments and Principles. Toronto: D.C. Heath, .

   Forty-four laboratory activities, both short and long term, are provided. Cautions are provided where appropriate; however, some laboratory activities use chemicals which may require additional care. A teacher's guide is available.

4. Parry, Robert, et al. Chemistry: Experimental Foundations, 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, 1982.

This most recent revision of the former CHEMS text adequately develops the core topics. Additional detail is provided to allow topics to be presented in greater depth. In addition, practical applications, career examples, and extensions are provided in segments at the end of many chapters. A teacher's guide is available.

Parry, Robert W., et al. Chemistry: Experiments and Principles Laboratory Manual, 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, 1982.

Both short- and long-term laboratory activities are provided. Cautions are provided where appropriate; however, some laboratory activities use chemicals which may require additional care. A teacher's guide is available.

5. Smoot, Robert C. Chemistry: A Modern Course. Columbus, Ohio: Charles E. Merrill, 1983.

The core topics in Chemistry 200 and 300 are adequately covered; however, the development of some topics does not follow the sequence which is suggested in the curiculum guide. Sample problems are presented where appropriate. In addition, information about scientists and chemical technology is presented at the end of a number of chapters. The reading level is adequate for the average Chemistry 200 student. A teacher's guide is available. Solving Problems in Chemistry is a supplementary source of additional problems and exercises.

OPTIONS (refer to ALCHEM under "core" for information about ALCHEM modules).

1. Hill, John W. Chemistry for Changing Times, 3rd ed. Minneapolis: Burgess Publishing, 1980.

This soft-covered text attempts to provide understanding about chemical principles through approaching an application. This text is a primary support for the content in a number of options, both in Chemistry 200 and 300. The reading level is satisfactory for most Chemistry students.

2. Stine, William, R. Applied Chemistry, 2nd ed. Toronto: Allyn and Bacon, 1981.

This text provides content for a number of optional topics in both Chemistry 200 and 300. The chemical principles, historical background, alternative positions on some issues, problems and technical processes are integrated to provide a reasonable amount of depth in the topics. Topics which are normally absent in most chemistry texts, such as immunochemistry, chemotherapy, food chemistry, and radiochemistry, are developed to a reasonable depth. This text is useful both for students and/or teacher reference.

3. Jarvis, Bruce, and Mazzochi, Paul. IAC: Form and Function: An Organic Chemistry Module. New York: Harper and Row, 1978.

This soft-covered module includes both laboratory activities and content. Basic organic chemistry is continously related to roles in

APPENDIX B

SCIENCE PROCESS SKILLS

An important goal of science instruction in Manitoba schools is to encourage students to become increasingly active investigators of science. Instruction in the processes of science begins in the elementary grades and continues through high school. Following is a list of the process skills that the program aims to develop and definitions.

Observing - Competence in using the senses and mechanisms for extending these senses in the collection of data from physical phenomena.

Classifying - Competence in grouping articles, objects and ideas on the basis of some observable physical and chemical attributes.

Quantifying - Competence in using numbers and in measuring length, weight, area, volume, concentrations and rate of change in physical phenomena.

Formulating Hypotheses - Competence in making an hypothesis (if . . . then statement) regarding the causes of a phenomenon or the relationship between two variables.

Making Operational Definitions - Competence in stating the operation to be performed and the observations to be made in applying a definition to an experiment.

Controlling and Manipulating Variables - Competence in making decisions concerning the control and manipulation of objects or conditions in an experiment, and in arranging conditions.

Interpreting Data - Competence in getting the most out of data without oversimplifying, in drawing conclusions supported by the data, and in considering alternative explanations on the basis of supplied or observed data.

Formulating Models - Competence in building both physical and mental models to account for phenomena.

Communicating - Competence in describing an experiment so that an individual who has not seen it can carry it out.

Inferring - Competence in drawing more than one inference or conclusion from a set of data, in demonstrating that an inference can be tested by applying known tests to the properties of objects, and in distinguishing between observations and inferences.

Predicting - Competence in conducting experiments to test predictions of relationships between two measurable quantities.

Experimenting - Competence in planning, conducting and communicating an experiment in which the problem is clarified, hypotheses are stated, observations are made, and data is interpreted. This process depends upon the use of all the other processes.

living organisms and industry. Topics, such as pesticides and sex attractants, photochemistry, drugs, and chemical warfare, allow this module to be used in a number of options in an interesting way. The laboratory activities attempt to use inexpensive and safe chemicals, when possible. Appropriate cautions are provided where needed. A teacher's guide for this unit is available.

4. Gordon, Glen and Keifer, William. IAC: The Delicate Balance: An Energy and the Environment Chemistry Module. New York: Harper and Row, 1980.

   This soft-covered module includes both laboratory activities and content. The optional topics of water environment and air are supported by this module. The module is also useful in examining the environmental effects of heat and alternate sources of energy. The laboratory activities attempt to use safe and inexpensive chemicals when possible. Appropriate cautions are provided. A teacher's guide is available for this unit.

5. Ashcroft, Ken, et al. Action Chemistry Series Modules. Toronto: Book Society of Canada Limited.

   Chemistry of Photography, SI ed. 1980. 48 pages.

   Chemistry of Metallurgy, SI ed. 1980. 46 pages.

   Chemistry of Man and Molecules, SI ed. 1980. 58 pages.

   Water, Chemistry & Ecology, SI ed. 1979. 58 pages.

   These soft-covered modules support specific topics within the options. A large amount of generally simple, inexpensive experiments are blended with chemistry and some geographical content. The material emphasizes application in a Canadian content. The modules are limited in the number of questions or problems which are available.

6. Summerlin, Lee. Chemistry of Common Substances. Morristown, NJ: Silver Burdett, 1978.

   This laboratory manual is useful in providing activities in a number of topics such as consumer chemistry. A wide variety of activities, which generally use safe and inexpensive materials, are provided.

7. Kowalski, Stephen, W. Consumer Science: Text and Laboratory Manual. Minneapolis: Burgess, 1981.

   This manual provides both content and laboratory activities. A wide variety of potential activities and approaches are provided for the development of consumer chemistry.

8. Webb, Madelyn, F. The Canadian Environment: Data Book on Energy and Environmental Problems. Toronto: W.B. Saunders, 1980.

   This is a teacher's reference which provides useful Canadian data in the areas of energy, water and air environments, pesticides, metals, and land use.

9. Eby, Denise, and Tatum, Roger. A Consumer Chemistry Learning Acitivity. Seattle, Washington: Unigraph.

The Chemistry of Food, 1978.
The Chemistry of Beverages, 1978.
The Chemistry of Food Additives, 1977.
The Chemistry of Soaps, Detergents and Cosmetics, 1977.
The Chemistry of Over-the-Counter Drugs, 1977.
The Chemistry of Soils and Fertilizers, 1977.

These packages include ditto mastersamd a teacher's guide. Chemistry content, and laboratory and consumer-oriented activities are integrated within the packages. The materials are very flexible in that a package can be used either to support completely or supplement some optional topics, or single activities or sections can easily be produced as multiple copies.

10. Reid, Norman. The Amsyn Problem. Glasgow, Scotland: The Scottish Council for Educational Technology, 1978.

This simulation helps students to examine the various interactions and criteria which must be considered when an industrial plant has to meet new anti-pollution criteria. The appropriate chemistry and information is provided about a variety of factors and trade-offs which have to be considered. Student booklets, a tape and slides are provided in the package. Although this was developed in Scotland, the model is readily transferable to situations within the topics of metallurgy or environmental chemistry. This represents some of the few materials which allows students to examine the kinds of decisions which have to be made in the interaction of chemical processes with societal needs. Also included in the series produced by the Scottish Council are the following titles which support various options: Vinyl Chloride Problem, Titanium: The Aerospace Metal, Zinc and You, Nitrogen for the Nineties.